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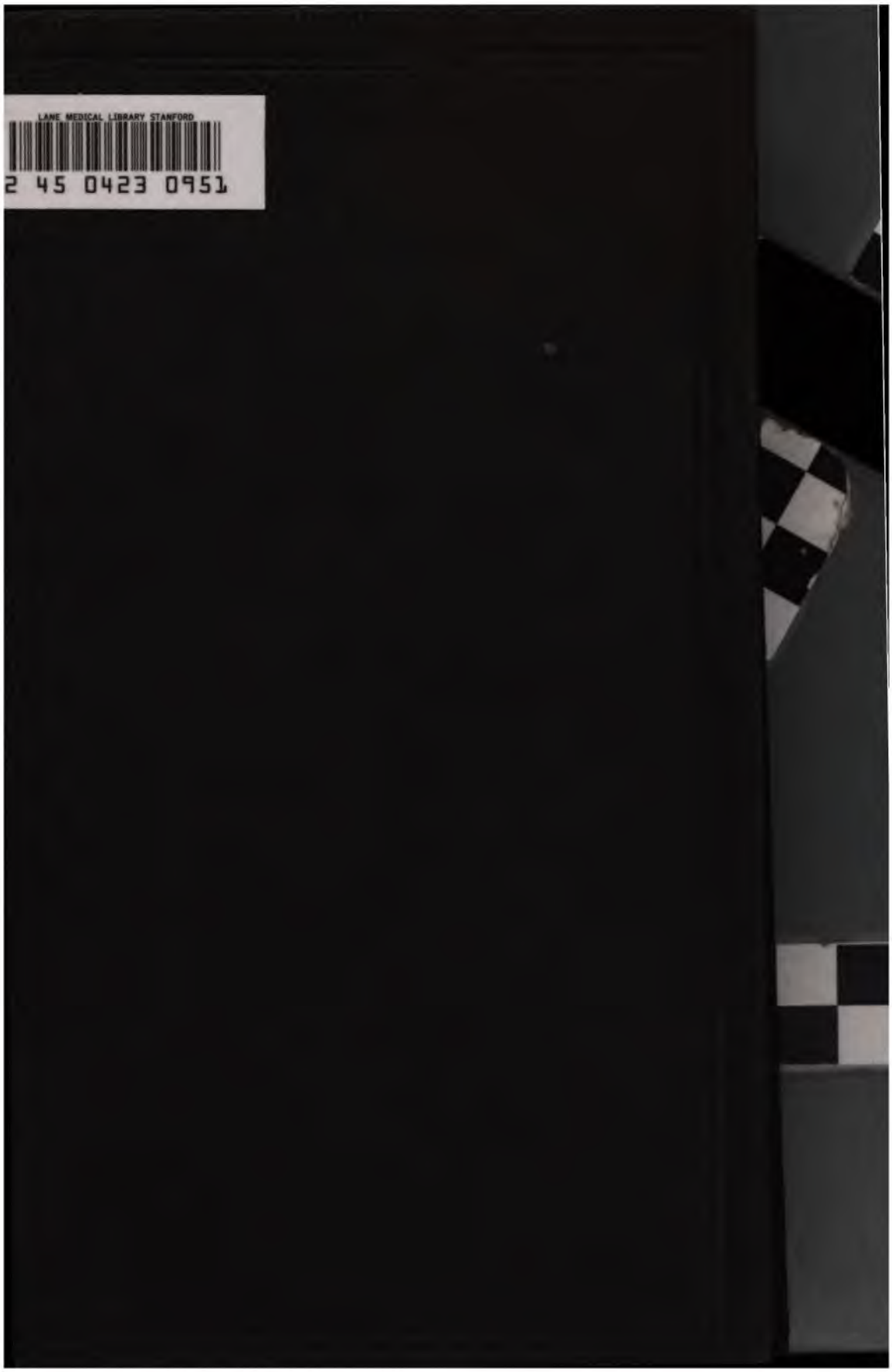
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AGRICULTURAL EXPERIMENT STATION.

REPORT OF WORK

OF THE

AGRICULTURAL EXPERIMENT STATIONS

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REPORT OF THE PROFESSOR OF AGRICULTURE AND DIRECTOR OF THE EXPERIMENT STATIONS

TO THE

PRESIDENT OF THE UNIVERSITY.

E. W. HILGARD, DIRECTOR.
E. J. WICKSON, ACTING DIRECTOR, 1892–3.

26865

SPECIAL NOTICE TO PERSONS SENDING SAMPLES FOR EXAMINATION TO THE EXPERIMENT STATION.

1. The work of the Station being designed for the benefit of the agricultural public, we do not undertake to investigate matters of purely private interest, unless conclusions subserving the public interest can be drawn therefrom. The Station does not undertake to solve riddles for the merely curious. It should, however, be understood that the examination of soils, waters, insects, plants, and other natural or new materials of interest to the agriculturist forms part of the general plan of investigation of the resources of the State. So far, therefore, as any such examination fills a gap in our knowledge of the State, it will fall within our province, even though for the moment benefiting only an individual. Special directions for the proper taking of soils and waters will be sent on application.

2. In order to insure attention and examination, every sample sent must be accompanied by a full statement of the origin, mode of occurrence, or special nature of the object sent, with a mention of the particular points upon which information is desired, and the object in view in asking the question. Without such information the Station would in many cases have to go to an amount of trouble quite disproportionate to the value or importance of the object to be attained, nor would the public interest be subserved.

3. Every package sent should always be distinctly marked with the sender's name and post office, even when a letter is inclosed in it. Whether sent by mail or express, all packages must be *prepaid by the sender*, unless sent by special request of the Station.

4. Reports of such examinations will be sent by letter when completed, and the results will be published in the ensuing annual reports of the Station. The annual reports and bulletins will be mailed free to any resident of the State requesting the same.

Remember that your package is but one of many that may arrive on the same day, and that our staff cannot afford to spend their time in comparing and identifying the handwriting on letters and packages; also, that for the same reason immediate action upon the sample cannot be expected, but that you must take your turn among the rest. If for particular reasons an immediate answer is desired, state the fact and the reasons therefor, and so far as possible examination will be expedited.

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EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA, 1893-94.

CENTRAL STATION (Berkeley, Alameda County).

E. W. HILGARD, Ph.D., LL.D. (Professor of Agriculture), Director and Chemist.
E. J. WICKSON, M.A. (Associate Professor of Agriculture, Horticulture, and Entomology), Superintendent of Agricultural Grounds.
E. L. GREENE, Ph.B. (Associate Professor of Botany), Botanist.
R. H. LOUGHRIDGE, Ph.D. (Assistant Professor), Agricultural Geologist and Agricultural Chemist.
C. W. WOODWORTH, M.S. (Assistant Professor), Entomologist.
M. E. JAFFA, Ph.B. (Instructor), First Assistant Chemist in Agricultural Laboratory.
ARTHUR P. HAYNE, Ph.B. (Instructor), Assistant in charge of Viticulture and Olive Culture.
GEO. E. COLBY, Ph.B. (Instructor), Second Assistant Chemist in Viticultural Laboratory.
C. H. SHINN, A.B., Inspector of Stations.
EMIL KELLNER, Foreman of Station Grounds.
F. T. BIOLETTI, B.S., Foreman of Viticultural Cellar.
A. V. STUBENRAUCH, Clerk to the Director.

SIERRA FOOTHILL STATION (near Jackson, Amador County).

R. C. RUST, Patron; Jackson.
GEORGE HANSEN, Foreman; Jackson.

SOUTHERN COAST RANGE STATION (near Paso de Robles, San Luis Obispo. County).

GEORGE R. ADAMS, Patron; Paso Robles (resigned June, 1894).
R. W. PUTNAM, Patron; Paso Robles (appointed June, 1894).
W. H. TYSON, Foreman; Paso Robles.

SAN JOAQUIN VALLEY STATION (near Tulare City, Tulare County).

A. J. PILLSBURY, Patron; Tulare City.
JULIUS FORRER, Foreman; Tulare City.

SOUTHERN CALIFORNIA STATION (near Pomona, Los Angeles County).

RICHARD GIRD, Patron; Chino.
K. MCLENNAN, Foreman; Pomona (resigned October, 1893).
J. W. MILLS, Foreman; Pomona (appointed October, 1893).

CHICO FORESTRY STATION (near Chico, Butte County).

C. C. ROYCE, Patron; Chico (resigned June, 1894).
R. F. PENNELL, Patron; Chico (appointed June, 1894).
A. B. BOLAND, Foreman; Chico.

SANTA MONICA FORESTRY STATION (near Santa Monica, Los Angeles County)

H. J. KRUCKEBERG, Patron; Santa Monica.
WM. J. STRACHAN, Foreman; Santa Monica.

VITICULTURAL STATION (under private auspices).

EAST SIDE SANTA CLARA VALLEY STATION; Mission San José, Alameda County. John Gallegos, Patron; Mission San José.

COURSES IN AGRICULTURE AT THE UNIVERSITY OF CALIFORNIA.*

AGRICULTURAL CHEMISTRY—

1. *General Course.* (*a*) Chemistry and Physics of Plants, three times a week during the first term. (*b*) Soils and Theory of Culture, three times a week during the second term. Professor Hilgard and Assistant Professor Loughridge.
2. *Vinification.* Lectures twice a week during the first term, with practical cellar-work. Mr. Hayne and Mr. Bioletti.
3. *Agricultural and Viticultural Laboratory.* Twelve to fifteen hours a week during both terms. Mr. Jaffa and Mr. Colby.

AGRICULTURE AND HORTICULTURE—

4. *General Course.* Three times a week during both terms. Associate Professor Wickson.
5. *Viticulture and Olive Culture.* Twice a week during the second term. Mr. Hayne.
6. *Special Courses* given as called for.

ENTOMOLOGY—

7. *Elementary and Economic Entomology.* (*a*) Lectures and laboratory work, twice a week during the first term. (*b*) Supplementary laboratory work, once a week during the first term. Assistant Professor Woodworth.
8. *Apiculture.* (*a*) Lectures, laboratory and apiary work, twice a week during the second term. (*b*) Supplementary laboratory and apiary work, once a week during the second term. Assistant Professor Woodworth.
9. *Parasitic Plant Diseases.* Lectures twice a week during the first term. Assistant Professor Woodworth.
10. *Systematic Entomology.* Lectures three times a week during the second term. Assistant Professor Woodworth.
11. *Structural Entomology.* Lectures three times a week during second term. Courses 10 and 11 are given in alternate years. Assistant Professor Woodworth.
12. *Entomological Laboratory.* Two or three times a week throughout the year. This course can only be taken with or after Courses 9, 10, or 11. Assistant Professor Woodworth.

AGRICULTURAL SEMINARY—

13. Elementary course for study of current agricultural literature, once a week during both terms. Associate Professor Wickson and other instructors.

*In addition to the general requirements in mathematics, literature, languages, and general sciences; for detailed description of which see the General University Register.

LETTER OF TRANSMITTAL,

AND REPORT ON INSTRUCTION AND EXPERIMENT STATION WORK.

President MARTIN KELLOGG:

DEAR SIR: I transmit herewith the manuscript of the report on the work of the Experiment Station since the issuance of the previous one (1891–92), for your approval and transmission to the State Printer. In actual time, it covers the work of the financial year 1892–93 (under the eminently satisfactory direction of Professor Wickson) and up to January, 1894. In view of the unforeseen delays in its completion, some of the more important investigations of the first half of the year 1894, made in the laboratory of the Central Station, have also been included, so as not to unduly delay their publication, since financial considerations forbade their issuance in bulletin form.

Instruction.—In view of the intimate connection existing between the Experiment Station work and that of instruction, it becomes necessary to discuss both conjointly, since with one exception the entire Station staff takes part in both. The double duties thus imposed must account for the delay in the transmission of this report, which should have been ready six months ago; in this instance the preparation of the report on the exhibit of the soils of the United States at the Chicago World's Fair, made to the World's Fair Committee, and the preparations for the Midwinter Fair, have imposed additional delay; and the entire summer vacation has been occupied by the staff in its completion.

I must, in justice to this department, call attention to these facts, since the relatively small number of students attending some of the agricultural lecture courses is frequently made the basis of suggestions toward the reduction, instead of increase, of our working force. It should be abundantly apparent to any one that a lecture course involves the same amount of time and forethought with small as with large classes; so that if agricultural instruction is to be given at all in accordance with the provisions of the two Morrill Acts, a proper staff, in numbers as well as in specific qualifications, must be provided for the purpose. Among the deficiencies in our provision for instruction, to which I have called attention annually for many years past, is the absence of a chair of Veterinary Science; a serious gap, which exists in but few of the agricultural colleges of the United States. While fully aware of the financial difficulties which at present confront the University, I cannot omit to enter once more a *caveat* on this subject.

While in the case of the lecture courses the number of students forming each class does not alter the labor involved, it is quite otherwise with laboratory students. Of these, we have during the last three years had as many as could be accommodated with work-desks; and as each one requires individual attention on the part of Instructors Jaffa and Colby, the station work by these assistants has thereby been materially interfered with, and but for the temporary appointment of extra help (Mr. Marvin Curtis) during a portion of the last session, would now be hopelessly in arrears. As the interest in this work on the part of the

population, therefore its volume, increases, it will become indispensable to provide either for additional aid in instruction, or in the experimental work. Fortunately, the thesis work of some advanced students, who chose questions requiring investigation, has in a measure served to complement our work; and hence their theses are reproduced with this report.

Lectures and Correspondence.—Another line of duty which adds materially to the labors of some of the staff, is the preparation for, and attendance at, Farmers' Institutes, Conventions, and other meetings of similar character, coupled with the fact that in most cases the papers read or discourses made have to be prepared for publication. A report of this work, by Professor Wickson, is transmitted herewith. The instruction thus given to public audiences, and to the readers of the proceedings, should fairly be placed to the credit of instruction in the College of Agriculture; no less than the 2,500 to 3,000 letters written annually by the different members of the staff. This, as well as the writing and making-up of the reports and bulletins, are duties which considerably more than offset the Extension Courses of any other department of the University.

It should be understood that out of the numerous examinations made of specimens sent to the Station, and reports made thereon, a large proportion are omitted from even mention in the present report; not being of sufficient general interest, save as links in the chains of facts which should ultimately serve for a complete description and map of the agricultural and industrial features of the State.

Equipment for Instruction and Work.—I cannot omit in this connection to call attention again to our still very deficient equipment as regards both instruction and experimental work in the College of Agriculture. In this we lack many conveniences required for effective demonstration and quick execution of laboratory work, which are elsewhere considered indispensable in order to keep abreast of the progress made in this respect. The lack of these appliances involves a vast amount of time lost in mounting, dismounting, and reconstructing apparatus, that should be duplicated several times over in order to work to the best advantage; not to speak of the disadvantage to instruction which results from imperfect means of demonstration. I respectfully call attention to the statements made in connection with this subject in the special report on European Agricultural Colleges in a subsequent part of this report.

I may add that the new and important connections established by us with foreign institutions, as a result of my visit to Europe, have added materially to the burden of correspondence, and that hereafter an absolutely essential qualification of the Director's Clerk must be an adequate knowledge of at least one of the modern languages (either German or French), together with a sufficient practice in typewriting, and if possible stenography, to relieve the Director of personal burdens which it will become impossible to bear unassisted.

Early Course for Students—Lower Schools.—In reference to possible increase of students in the agricultural course, it is hoped that the modifications made in remodeling the course during the last session will be conducive to that end. As it has seemed desirable that the agricultural students should come in contact with the department instructors earlier in the course than has been the case heretofore, so as to begin their distinctive studies at once upon entering college, arrangements have been made for weekly exercises of a seminary character, taking as a

basis the current literature of agricultural journals and station bulletins, thus familiarizing them with the problems of modern agricultural science, and interesting them in the questions of the day. These exercises are open to all students interested, and while under the general charge of Associate Professor Wickson, will be participated in successively, according to the nature of the subjects to be presented, by all the instructors in the agricultural courses proper.

Two-years' Course.—In the absence of any instruction in agricultural topics in the schools below university grade, those who would otherwise attend such instruction in the lower schools usually come to the University for two years, or less; and under the present regulations they can only enter in the category of "special students." These regulations are frequently, however, but illy applicable to the cases of such students, in more than one respect. It would seem advisable, in view of the fact that two-year courses are most in demand, that they should be definitely recognized and formulated, and that a definite certificate on the part of the College of Agriculture and of the University should take the place of the mere certificates of record heretofore given in such cases.

It may be objected to this plan that such recognition might diminish still further the number of students taking the full four years course, and I confess that this consideration has prevented me from making the above recommendation at an earlier time. But in my study of the conditions of agricultural education in Europe, I have become convinced that the paucity of students in the agricultural course of university grade is largely due to the fact that definite careers for students pursuing such a course are, in the nature of the case, very much less abundant in this country than in Europe, where government positions and the superintendence of large properties offer them a larger attractive field. While, therefore, I hope and believe that with the constantly increasing necessity for a more rational system of agriculture, due to the progressive exhaustion of our virgin soils, the demand for thoroughly and professionally trained agriculturists will steadily increase, and while I also believe that the University diploma should be rigorously reserved to those who in addition to such professional training are otherwise culturally equipped to become leaders in such profession, I also think that so far as in us lies, the present demand should be met on our part by such arrangements as will make the educational advantages of the College of Agriculture freely available to all those who desire to use them, so far as their previous preparation will permit.

Training for College and Station Work.—Among the important functions required of our agricultural colleges, and the need of which is not yet sufficiently appreciated even by themselves, is the education of men specially trained to fit them for positions in such colleges and stations. It is notorious that, thus far, but too many of the men occupying these positions are merely specialists in the particular branch represented by them, and are unable themselves to discuss the bearings of the results of their own work upon the general interests of agriculture. This narrowness of educational knowledge, inseparable from the sudden establishment of so many agricultural colleges and experiment stations, must be held responsible for a great deal of the crude and undigested matter now often found in station reports. Nor can men fitted for these positions be properly educated in the popular schools of agriculture so often urged as likely to be more useful than those of university grade. It

cannot be too often nor too earnestly repeated that the first condition of reform or progress in any line is the availability of properly qualified leaders. Late events have emphasized this as regards industrial and social conditions in other branches; it is no less emphatically true in reference to the agricultural industry.

EXPERIMENTAL WORK.

Viticulture and Olive Culture.—The resignation by Mr. Paparelli of the assistantship in charge of Viticulture and Olive Culture, left the department with the unelaborated record of considerable work done by him during his incumbency, which, in the absence of his personal coöperation, it will be difficult to utilize fully. Such losses are among the unavoidable infelicities attending a frequent change of workers.

His successor, Mr. A. P. Hayne, has however taken hold energetically of the problems of both branches of his subject. His paper on "Olives and Olive Oils," being a somewhat extended revision of a bulletin previously issued, is hereinafter given; and active preparations have been made for the continuation of similar studies during the present season by the issuance of circulars to olive growers, from whom it is hoped an extensive and varied supply of material for investigation will be obtained. We may thus hope to forestall the repetition of the numerous expensive mistakes heretofore made in connection with the olive industry.

In the line of *Viticulture*, Mr. Hayne, assisted by Mr. Bioletti, has nearly completed the report on the work done on white-wine grapes, which will complete the one already issued on red-wine grapes in 1892. This publication will, in a measure, round off that portion of the work which was specially designed to establish some definite starting points for comparison of the composition and quality of grapes, musts, and wines from the different climatic regions of the State. The same kind of work, it is true, must be continued on a somewhat reduced scale with the material now supplied by the outlying culture sub-stations. It is now intended, however, to resume and continue on a more extended scale the experiments on wine fermentation and conservation, specially with reference to the possible improvement of the product by selected ferments, which has yielded such important results in Europe. Now that there seems to be hope of a proper discrimination of the quality of wines in commercial circles, the preparation of the best possible product from a given material assumes financial importance.

The report on white-wine grapes will probably be ready for the press soon after the present one, and will as heretofore be issued separately.

Chemical Work on Wines and Fruits.—In addition to the usual series of analyses of musts and wines, belonging to the regular viticultural work, an extended series of analyses of fruits, among which olives take a prominent place, has been made by Assistant Colby during the period covered by this report; as shown in the record and discussion given below. The work on olives especially has attracted wide attention on account of its important practical bearing on the selection of varieties to be planted in different regions and for different purposes.

Agricultural Laboratory Work.—The analyses of feeding stuffs of various kinds, made at the suggestion or request of dairymen and stock-breeders, is becoming more prominent in the Station work, and has occupied a not inconsiderable portion of the time and attention of Assist-

ant Jaffa; besides the usual complement in the way of examinations of soils, waters, fertilizers, rocks, clays, and other materials too numerous to mention, constantly being sent in from all parts of the State. It may become necessary, in order to relieve the pressure, to circumscribe more closely the character of the examinations which the Station will undertake to make. It has been said that the wide scope now given interferes to a certain extent with the legitimate occupation of commercial chemists. While it is true that any such interference by the Station is to be avoided, as is done in the case of nurserymen in our distribution of seeds and plants, it is also true that the reason why so many demands are made upon the Station for work of this kind is not so much the avoidance of a fee (which is very commonly freely offered) as the desire to obtain, besides the columns of figures usually furnished by such chemists, intelligent and disinterested interpretations of the results, together with the authority of the Station for the same. It is this very kind of demand which has in Germany (as hereinafter shown) increased enormously not only the work of the experiment stations (for which a moderate fee is charged), but also the aggregate amount of chemical work asked for in connection with agricultural interests.

Entomology and Plant Diseases.—Assistant Professor Woodworth's courses in general and economic entomology and plant diseases have been well attended during the past two sessions, between twenty and thirty students taking part in them, both in the laboratory and lecture-room. A special course in apiculture (bee-keeping) has been given for the first time during the session 1893–94, and will be regularly continued hereafter. In addition, Professor Woodworth has made numerous examinations of specimens of insects, diseased plants, etc., sent for inspection and identification and for suggestion of remedies. This has involved quite an extended correspondence, but the results are not generally of such a nature as to be utilized in this report. He has also attended a number of Farmers' Institutes.

Miscellaneous Chemical and Editorial Work.—A large number of minor examinations, made in answer to requests, accompanied by specimens, are constantly being made by Assistant Professor Loughridge, as well as by myself personally, in cases where such examinations involve, with only a limited amount of laboratory work, the exercise of a great deal of judgment. Such examinations, likewise, must largely remain without notice outside of the record books; although involving the expenditure of considerable time, as well as voluminous correspondence.

In addition, editorial work connected with the issuance of reports and bulletins devolves mainly upon Professor Loughridge, together with the preparation of the photographs which have now become an important part of the record of the Station. The illustrations in the present report are copies of such photographs. Professor Loughridge has, moreover, been steadily engaged in the pursuit of chemico-physical soil studies of a general character whenever time permitted, besides acting in my place in the instruction of the classes in agricultural chemistry whenever absence or other causes have prevented my personal performance of that duty.

The Work of the Culture Stations.—In view of the predominance of fruit-growing in California, the chief interest in the culture experiments at the several sub-stations has centered in the outcome of the orchards and vineyards planted at the time of their establishment. As a neces-

sary consequence, results of such cultures are delayed for the number of years required to bring the trees and vines into bearing; and popular impatience has not always kept this fact in view. The time has now come when, after the lapse of from five to seven years, definite and valuable results may be looked for; and the extended reports on the several sub-stations hereinafter made by Inspector Shinn are an earnest of such results. That these, in a very large proportion of cases, will show a record of failures quite as heavy as of successes, is to be expected from the very nature of the experiments, which are intended to show what cannot, as well as what can, be done with certain species and varieties of fruits in the several climatic regions. The failures are just as important to the farmer as the successes, since they will prevent him from investing his money and efforts in profitless directions.

The management of these sub-stations from a distance, and with only occasional visits from the Inspector and Director, under foremen necessarily possessing little or no previous experience in experimentation, is far from an easy problem. It will be greatly facilitated when, in the progress of agricultural education in this country, there shall have been turned out from our own institutions a larger number of men specially qualified for the combination of practical scientific and administrative functions required in these positions. It may be confidently expected that as the utility, not to say necessity, of a large number of experimental sub-stations on our vast domain of indefinitely varied character becomes better understood, the number of such stations, and consequently the demand for well-qualified foremen, will become quite extensive and offer ample opportunities for employment to students educated in the agricultural colleges. Such positions will then, of course, require higher compensation than is now given our foremen, who at present receive merely gardeners' wages. Considering this limited inducement, I may say that at this time our foremanships are quite satisfactorily filled (one of them, the South California Station, by a former student who had a two-years' training at the College of Agriculture), and under the efficient supervision of Inspector Shinn, excellent work is being done.

In the case of three of the stations, located near to centers of population accessible by railroad, the work is well appreciated by the farmers of the regions concerned. Unfortunately, the station representing the foothill region, though excellently well located as regards soil and climate, still remains remote from railroad connection, contrary to the reasonable expectations entertained at the time of its establishment. This isolation is not conducive to its being appreciated by the fruit-growers of the foothills, who are chiefly interested in its operation; and are located mainly in Placer County, through which passes the Central Pacific Railroad, one of the great thoroughfares of the continent; at the same time the running expenses of this station are greatly increased from the same cause. It is, perhaps, to be regretted that at the time when its establishment was first contemplated no response to our invitation for offers of land and buildings was received from that prosperous region which initiated successful shipment of California fruits to the East, and has ever remained distinguished for the high quality of its products.

It is, of course, obvious that the four general culture stations thus far established outside of the Central Station at Berkeley, are not nearly sufficient to cover, in their cultural results, the immense agricultural area of

California. But it is doubtful that even with the utmost restriction and economy in the operation of these stations after they are fully equipped, even one additional culture station could be maintained out of the fund at present devoted to the purpose, viz.: the $15,000 appropriated for experimental purposes under the Hatch Act. If additional stations are desired for *e.g.* the Sacramento Valley, the northern interior counties, the northern and southern coasts, and many other climatic and soil conditions not now represented, additional means will have to be provided from some source.

It is proper to state in this connection, that in consequence of the reduction of the University appropriation for the expenses of instruction and experimentation at the Central Station (from $8,000 to $6,000 per annum), it became necessary to suspend the issuance of bulletins during the past financial year. It has therefore been thought imperative to so restrict the expenditures of the culture stations as to enable us to defray from the Hatch Fund the expenses of issuing bulletins as heretofore. It is manifest that these publications are absolutely essential to the appreciation and practical utility of the Station work; and that (since there has been no increase of the appropriation for the coming financial year) it will be better to restrict the work than to omit the publications. While our bulletins may properly claim the right of publication through the State Printing Office, as is done with our reports (and should be done in the case of the longer and less pressing bulletins), yet the long delay usually inseparable from the use of this channel, renders it necessary to supplement it, at least, by the issuance of matter of immediate interest at the expense of the Station fund, as is done elsewhere.

The two Forestry Stations, which, by an Act of the last Legislature, were transferred to our care, unfortunately with a very inadequate appropriation for running expenses or improvements, have been actively taken in hand so as to render them productive of useful results within the shortest possible time that the nature of the case permits. The gratuitous distribution of trees, formerly made from these stations, and which formed a source of complaint against them on the part of nurserymen as interfering with their legitimate trade, has been discontinued; the small amount of stock remaining on hand having been distributed to public schools applying therefor. As shown in the detailed report of the Inspector, much has been accomplished during the past financial year in placing these stations on a practical working basis; but it will be necessary for the next Legislature to make a more adequate provision for their maintenance, if they are to be continued. No respectable or practically useful showing can be made with the $2,000 per annum heretofore granted for the purpose in lieu of the $10,000 expended annually by the Forestry Board.

The Distribution of Seeds and Plants, as hereinafter reported by Professor Wickson, continues to form a highly acceptable and useful portion of our culture work. Our former publications containing the reports returned from persons throughout the State who have been recipients of such distribution, are in such constant demand that before long they may in substance have to be reprinted. It is obvious that such reports, when made by careful persons (and this is usually obvious upon their face), successfully replace, for the time being and for the plants concerned, the operations of a local culture station.

As from the nature of its location in an exceptional climatic belt, the cultures of the Berkeley Central Station are not representative of any extended climatic region, one of the chief functions performed by it is the growing of seed and stock for these distributions, as well as for the outlying culture stations, and for effecting exchanges with foreign institutions, societies, and Boards of Agriculture. These exchanges are rapidly assuming a wide scope and importance, and now extend all around the globe, so as to enable us to procure seeds and plants giving promise of successful culture in California, or which are otherwise of interest, from the most remote locations, with little expense beyond postage. Reference to the list of donations and of publications received will illustrate these facts.

The new *plant-house* now happily in progress of construction will, when completed, serve to utilize, both for instruction and experiment, a large proportion of the interesting plants received; of which several generations have heretofore perished, in consequence of lack either of space or of proper protection when grown. The wide climatic range embraced by the State of California, from the Oregon line to Mexico, compels us to provide for a correspondingly wide range of vegetable growths adapted to these numerous climates. We cannot properly propagate in the open air at Berkeley many of the culture plants adapted for trial in Southern California. Moreover, instruction in general as well as agricultural botany imperatively requires that a wide range of plants, illustrative of the vegetation of the whole globe, as far as possible, should be accessible to both students and instructors. Such illustrations are deemed essential in all educational institutions elsewhere; and however tolerant our climate may be, it does not exempt us from the necessity of providing artificial shelter for such foreign growths. The frequency with which the easy communication with foreign countries from San Francisco tempts our population to seek their fortunes in countries representing all climates from Alaska to the equator, render a cosmopolitan provision in these respects doubly important in our case.

I make this statement in view of the objection made in certain quarters, to the expenditure for the building of a plant-house, on the score of its being supposed to be unnecessary.

I am constrained to call attention to the fact that the improvements required to render the surroundings of the new plant-house sightly, not to say attractive, as they should be, cannot be defrayed out of the diminished appropriation of $6,000 for current expenses; nor can it be expected that the maintenance of the new plant-house will not cost more than that of the small and now decrepit structures that have heretofore been made to serve its purposes on the propagating-grounds. The new structure will enable us to take up lines of work for which thus far there have been no adequate facilities, however much needed; and we have reason to hope that while adding materially to the working facilities, it will also increase in a measure the attractiveness of the agricultural course.

Respectfully submitted.

E. W. HILGARD.

JULY 1, 1894.

WORK IN ENTOMOLOGY AND PLANT DISEASES.

To Professor E. W. HILGARD:

The work of instruction has in this department been greatly increased by the addition of advanced courses. The amount of additional work thus incurred can be seen from the fact that when I took up the work, two hours of class exercises with no laboratory was all that was offered in this subject, while now twenty credit hours, or actually forty hours, of work, including the laboratory, is now taken. The number of students at first was larger than now, because of the fact that entomology was required to be taught in the public schools. Now that that artificial stimulus has been removed the present may be considered to represent more nearly the normal attendance.

The other work undertaken by the department consists in a systematic study of the local insect fauna, more particularly investigation of the species and groups of direct economic bearing; a study of the remedies and means of prevention of insect and fungous injury, and the answering of letters of inquiry from all sources concerning insects and related subjects.

In the faunal studies a large amount of material has been accumulated, but only a small part of it has as yet been put in shape for publication. This material will be strictly scientific and hardly suitable for incorporation in the report of the Experiment Station, and will have to be published in scientific journals. It would be of advantage to the University if such material could be issued by the Station in a series of technical bulletins, as is done in the Department of Geology and Mineralogy. In other institutions this is also done.

The economic studies, as far as completed, are presented herewith. It has been the policy to report only completed work, or at least only such work as has brought out important results, so that what is presented at any time does not represent the work of that year, but rather the accumulated observations on some very few topics.

The correspondence has increased steadily, and become indeed, at times, quite burdensome, especially as it is, to so large an extent, a repetition of the same set of questions. The publication of special Bulletin A, giving the remedies most commonly in use, has proven a great help, and indicates that further publications of this type will be most useful.

Very respectfully,

C. W. WOODWORTH,
Assistant Professor of Entomology.

FARMERS' INSTITUTES UNDER THE AUSPICES OF THE UNIVERSITY.

To E. W. HILGARD, *Professor of Agriculture:*

SIR: Ever since the establishment of the University, the members of the teaching staff of the College of Agriculture have participated in the proceedings of societies and conventions devoted to agricultural progress and the dissemination of agricultural information. Such association with practical agriculturists has secured important results. It has brought the institution and its purposes directly to the attention of those whom it aims to benefit, and has won their interest and support; it has assisted the members of the college staff by increasing their knowledge of agricultural conditions and needs; it has also, to some extent at least, given the staff opportunity to observe the natural resources and characteristics of the State, which is indispensable to any adequate knowledge of the industrial adaptations of the region. It has been regretted that field work and local investigation have always been sorely restricted by the incessant demands for laboratory and office work at Berkeley, and by the fact also that no funds were provided for this purpose.

Still, as has been intimated, all possible participation in agricultural assemblies has been gladly undertaken, and an opportunity for freer intercourse with the people in their local meetings was welcomed. This opportunity arose with the request from the California State Grange, addressed to the Regents of the University, that Farmers' Institutes be undertaken under the auspices of the University in California, as had already been successfully done in Wisconsin and in other States. At the same time the Morrill Aid Fund became available, and the Regents deemed it fitting that a part of that fund should be used in the form of an extension of the instructional work of the College of Agriculture through the Farmers' Institute method. This action was taken by the Regents in March, 1891, and the beginning of Institute work under that name in this State was in April of that year. The effort has not advanced as rapidly as some of its promoters wished it might, and yet probably as much as was possible under the conditions limiting it. About the same time there arose farmers' movements which necessitated the devotion of much time from those who enlisted in them, and it was impossible to secure satisfactory attendance at Farmers' Institutes while people were so deeply engrossed with more ambitious organizations. Immediately upon the assumption of a quieter phase by the movement referred to, there arose the necessity for reforms in the marketing of some California products, and in nearly all the more progressive regions of the State local organizations for specific purposes, such as coöperation in production and marketing, and the like, were undertaken, and made constant requirements upon the time and spirit of the communities. The holding of Institutes served well in some cases to concentrate local efforts for specific purposes, as, for example, the coöp-

erative movement for marketing the raisin product of the San Joaquin Valley, began by the appointment of a committee by an Institute meeting held at Fowler; but it must be acknowledged that the active participation of farmers in nearly all localities during the last three years in frequent meetings for specific and imperative purposes has put limitations upon their active promotion of the Institute movement. Under these conditions it is not to be wondered at, perhaps, that the Institute should not advance rapidly in this State. In nearly all States there has been slow progress at first, but in most of them it has been attributed to the fact that the agriculturists were unused to assemblage for purposes pertaining to their own industry, and were slow to learn its benefits. In this State, where frequent meeting of farmers for all such purposes has been common for years, and where the number of local organizations in proportion to the population is far greater than in any other State, the Institute has only slowly commanded attention, because the farmers were already carrying forward so many organized efforts for their own enlightenment and business advancement.

This brief discussion is indulged in to meet any possible question as to why the Institute effort has not advanced more rapidly. Really there is no reason, perhaps, to consider it slow, though one might claim that such a democratic and untrammeled form of meeting, which makes no money requirement of participants and subjects them to no pledges or rules, save those of parliamentary practice, and which opens up to them all the sources of light and encouragement from agricultural science and practice, should be rapid and all-pervading in its command of public attention. It is answer enough to say that nothing of an educational character goes that way. As nearly as I can learn from reading, we have done about as much in three years as most other States have done. We are, in fact, just at the time in our Institute history when rapid progress should commence.

During the last three years Institutes have been held under the auspices of the University as per following statement:

Fresno County	10
Tulare County	3
Placer County	3
Alameda County	3
Sacramento County	1
Sonoma County	1
Los Angeles County	10
Santa Barbara County	2
Ventura County	1
San Bernardino County	1

This is, of course, a very uneven distribution of the Institutes geographically. It is due to the fact that the people in the counties have manifested interest in the work in varying degrees, as the numbers of meetings show, and that all the counties named surpass in interest the other counties of the State. Although my correspondence has covered a much greater list of counties, those named are the only ones which have shown their interest by the preparations which are required for the meetings on the part of the localities desiring them.

To show what requirements are made of localities I quote the following from the instructions for carrying on this work, as adopted by the Board of Regents:

(*a*) That the work proceed somewhat slowly at first, with the expectation that the number of meetings will increase as the people become informed of the character of

the Institute effort and its influence as a factor in the advancement of practical agriculture. Such has been the history of the work in those States in which the system has reached its best development.

(*b*) That, for a time at least, the work be allowed to proceed in directions which seem to welcome it; or, in other words, that the demand for the work, as shown by application and local preparation for it, shall indicate the direction in which the supply shall proceed. This is not only a natural course for the effort, but is at the same time a surety of local interest and coöperation, without which success is impossible.

(*c*) That it shall be understood that evidence of local interest and coöperation shall consist in local preparation for the meetings. That representatives of local agricultural societies or volunteer committees, or energetic individuals acting singly, shall undertake to arouse local interest, shall secure promises of participation from progressive agriculturists of the region (both men and women when feasible); shall provide suitable places of meeting, and whatever local printing may be desirable, and shall meet whatever expenses shall arise in the carrying out of their own plans.

(*d*) That whenever the officer of the University who is conducting this work shall be assured of trustworthy local interest of this kind, it shall be his duty to render the local participants every possible assistance in planning their meetings and in other preliminary preparations, and either he or some other member of the University staff shall attend in person all meetings which are understood to be held under University auspices.

(*e*) That such meetings, understood to be under University auspices, shall be conducted by the University representative, who shall conduct them under rules usual for the conduct of parliamentary bodies; that all such meetings shall be understood to proceed under the head of "special order," which shall be the improvement of agricultural practice and the education of the people in the sciences underlying it, the improvement of the home and the methods of home life, the advancement of intellectual culture and other matters calculated to render the meetings valuable, entertaining, and profitable, but that all vexed questions of politics, religion, socialism, and the like, shall be considered out of order. This course has been fully approved by Eastern experience with such meetings.

The conditioning of Institute work upon the degree of interest manifested by localities desiring it is in accordance with the best precedents. For example, in the State of Wisconsin, where Institute work has attained the highest excellence and at the same time the greatest popularity, and where the Legislature makes an annual appropriation of $12,000 for its prosecution, it is insisted that the locality shall share the burden and expense of the meetings. I quote the following from a circular issued July 3, 1894, by Geo. McKerrow, Superintendent of the Wisconsin Institutes:

> The University of Wisconsin, wishing to reach as far as possible all the agricultural portions of the State during the coming winter, respectfully asks that all those interested in the holding of Institutes in their respective localities, write the undersigned at Madison, expressing their wishes and stating number of inhabitants in village or town, seating capacity of hall, hotel accommodations, and leading agricultural industry followed in the locality.
>
> The locality asking for a meeting will be expected to furnish a hall properly heated and lighted for a two-days' meeting, and do all the local advertising free of cost to the University, while the University will furnish practical men to open the discussions, and also advertise the meeting to some extent, besides distributing two hundred copies of Bulletin No. 8, and other agricultural reading matter free of cost.
>
> We do not expect to be able to place Institutes at all points requesting them, but all can rest assured that their claim will be carefully considered by the University authorities, and those places where Institutes have never been held, as well as those that have made previous meetings a success, will be favorably considered, as far as possible.

It is evidently no part of a University's enlistment in Institute work to proceed upon the methods of showmen, to hire halls, bill the towns, and pay the expenses of lecturers upon the mere chance that the people will attend. There must be local manifestation of interest enough to show that this phase of University extension will be welcomed and made profitable.

In California, as shown above, this interest has differed widely in degree. In three counties there are local organizations for the express purpose of appointing meetings and securing the necessary local facili-

ties. Fresno County was first to adopt this plan. Los Angeles County followed this lead, and subsequently the sphere of the organization was enlarged to include all the counties south of the Tehachapi Mountains.

In order to show that the local preparation which is required is not formidable, I quote from a preliminary circular letter which I have used in reply to inquiries as to what it is necessary to do to have an Institute:

First—Be sure that you can rely upon enough people to work with you to succeed in creating popular interest which will bring a good attendance of both men and women to the sessions.

Second—Be sure you have enough speakers or readers of essays, and musicians if possible, to make the meetings both practically valuable and entertaining.

Third—Provide a suitable place of meeting, which shall be bright and comfortable, and not too large. It is better to be a little crowded than to have a small number scattered through a large, dreary hall.

Fourth—You need the sympathy and coöperation of the local newspaper men, so that they will give you good notices of the Institute and help in bringing the people together.

If you conclude you can master these four factors you may count upon success. A good way to determine these points is to call a meeting of all who will work with you in getting up the Institute, and canvass the subject. The programme should include some representation of every kind of farming which is followed in the region you expect to include in your Institute. All these subjects need not be embodied in formal essays or addresses, though as many as possible of them should be, because if a man or woman will write her facts or thoughts the results are apt to be more compact and tangible. But if some say that they "can't write," get them to be present and give their experience in the form of a talk and answers to questions. Get every man or woman in the region who is doing something better than it is generally done, to participate in the meetings. Short statements are better than long ones, and there should be a host of them, so as to touch every one's interest at some point and bring out a large attendance.

There should be some essays or talks from the ladies on home affairs, woman's work in agriculture, floriculture—any feminine subjects which they can present acceptably. The music may be both vocal and instrumental, as far as both can be provided for, and every neighborhood can furnish this either in solo or chorus or both. It helps wonderfully to enliven the meetings.

From this hasty sketch it appears that much work must be done by those in the locality who take an interest in the matter. The University instructs me to be useful in conducting such Institutes, and authorizes me to enlist other lecturers from the faculties of the University who may be disposed to participate, and pays all expenses of the University representatives. The expense of local arrangements are borne by the locality. Sometimes by the use of a church or schoolhouse (during vacation) and by securing the good will of the local newspapers, it is possible to have very good meetings with very little expense.

In the prosecution of the Institute work thus far I have attended meetings in all of the counties named above, and have visited some of the counties several times. Professor Hilgard has prepared special addresses for at least five Institutes. President Kellogg, Assistant Professor Woodworth, Mr. M. E. Jaffa, and Mr. A. P. Hayne have also participated in the meetings. It must be acknowledged that sometimes the requirements of the work are arduous, and occupy time which cannot be well spared from other University duties. The importance of it to the University and to the public is, however, unquestionable. In the future it will be necessary to engage assistance from qualified speakers outside of the University staff, as is the practice in other States where the work has attained large proportions. The measure of this help, and in fact of the movement as a whole, must depend upon the degree of interest which may be awakened.

The character of the meetings held thus far has been eminently satisfactory. The attendance has varied greatly, ranging from 50 to 200. In every case sharp interest has been manifested, and many resolutions have been adopted approving the effort on the part of the University. There has also been a very gratifying spirit displayed in contributing to the success of the meetings in the way of essays, addresses, and free

participation in the discussions which have arisen. A file has been kept of the matters of greatest interest which have been presented, so that an extended report of the Institute proceedings can be prepared for publication if arrangements should be made for it. It is very desirable that such report should be provided for. In this way a far greater distribution of the benefits of the effort could be secured and wider interest aroused. It is customary in other States to provide for such publication.

EDWARD J. WICKSON,
Associate Professor, in charge of Farmers' Institutes.

REPORT OF OBSERVATIONS MADE ON EUROPEAN AGRICULTURAL SCHOOLS AND EXPERIMENT STATIONS, 1892-93.

By E. W. Hilgard.

To the President of the University:

As stated in my application for leave of absence, it was my intention to combine with a year's travel in Europe, systematic observations on the agricultural schools and experiment stations of the continent, to be embodied in a report on my return. My plans in this direction were unfortunately very materially curtailed by the health conditions of my family and other circumstances beyond my control, which forbade extended travel and compelled more prolonged residence in single localities. As a consequence, my observations have been less varied than I could have wished, but made me thoroughly acquainted with a few of the most prominent institutions and with the general facts relating to the system; it is with these, therefore, that this brief report mainly deals. I propose, however, to continue and extend the study of the subject, for embodiment in future reports. Thus far my observations have borne mainly upon Germany, Switzerland, and France. But the brevity of time at my command constrains me to defer my remarks on the latter country to a future time.

GERMANY.

General Condition of Agricultural Education.—As a consequence of the minute political subdivisions that have existed in Germany in the past, the distribution as well as the organization of agricultural instruction and experimentation is not uniform over the various portions of the country. The establishment of the empire is of too recent date, and "particularism" is still too potent in some regions, to permit the more perfect unification of plans and methods that in some respects would be very desirable. Prussia presents in this respect more of a uniform organization than the other States of the empire, and may be most usefully studied.

Historically, schools of forestry have preceded those of agriculture proper. Forestry has from the outset held, in the estimation of the governing classes, a position materially higher than the pursuit of the peasantry; largely from its intimate connection with the "noble art of venerie," which was and is now deemed a worthy occupation for kings and nobles; it is only in China that the tillage of the soil is considered worthy of imperial hands. Trained foresters were needed, and hence training schools were established for them in various forms, in early times. It seems also to have been the failure of the old system of husbandry to produce satisfactory results on the royal "domaines" and on the large estates of the nobility, that first attracted governmental attention to the need of agricultural training-schools for the managers of these establishments, so as to make the latter maintain their accustomed incomes.

As the agricultural production of all countries has gradually come into competition in the world's market in consequence of the increased facility of intercommunication, the maintenance of these incomes at the point required for the accustomed high living of the proprietors has become more and more difficult, and has even resulted in the formation of an "agrarian party," whose programme is the "relief f the agricultural depression," by measures among which the partial repudiation or scaling-down of mortgages on landed properties is freely discussed. The only true mode of relief lies, of course, in the scaling-down of the former style of living on the part of the proprietors themselves, and in their personal participation in the task of bringing the methods of culture and production up to the highest level rendered possible by modern agricultural science and practice.

There is thus a demand for well-trained men to serve as managers of large landed estates and royal "domaines"; the more advanced members of the landed nobility, as well as the large landed proprietors not within that privileged class, also desire similar training for their sons. For these, of course, the most thorough scientific and practical training is needed; and it is from this class that the students of the agricultural colleges proper are most largely recruited. Another portion aims at employment as teachers in the lower schools of agriculture, and as lecturers ("*Wanderlehrer*") at what in the United States is now known as Farmers' Institutes. The numerous experiment stations, also, require a not inconsiderable number of men of similar training. Finally, the official land surveyors for the rural districts form an additional contingent. The training of these men falls mainly within the province of the university grade of agricultural schools, most of which are either integral parts of, or more or less intimately connected with, the universities. Such is the case, in Prussia, with the agricultural institutions at Berlin, Königsberg, Breslau, Halle, Kiel, and Bonn (Poppelsdorf); in Saxony, with the University of Leipzig; in Bavaria, with that of Munich. In all these, university professors form part of the faculty of the agricultural colleges proper, and vice versa; while students are admitted under one matriculation to the lectures of either. These facts are specially commended to the attention of those who, either from the standpoint of the old-school "humanities," or from that of the populist agrarian, would have the agricultural colleges of this country detached from the State universities.

Besides these agricultural colleges forming university departments, and embracing all branches of agriculture, there are a number of special schools, still of the university grade, but to a certain extent the outgrowth of local needs. Of these the forestry schools have already been mentioned (in Prussia, Eberswalde, and Minden); the veterinary colleges at Berlin and Hanover rank in the same category.

Most of these colleges have prescribed two- or three-year courses for those aspiring to government employ in the several branches. Coming as they usually do from the gymnasiums and "realschulen," they enter approximately with the preparation reached with us at the end of the sophomore year.

On a lower plane, and designed for the use of the middle and peasant classes, are two grades of agricultural schools scattered as yet too thinly and unevenly over the country. Of these, the higher grade may, on the literary side, be taken as representing the grade of our preparatory col-

leges; they teach not only the practice of agriculture, but also give short but systematic courses in the underlying sciences. They stand in a measure in place of the secondary schools for those who intend to pursue agriculture as a calling. In the school of Meissen, in Saxony, which may serve as a good representative of this class, the course consists of two half-year terms, and includes geometry, surveying, and drawing, besides elementary courses in botany, geology, general and as related to soils, agricultural chemistry, and physics, practical agriculture and horticulture, and stock-breeding; also national economy and legislation, and bookkeeping. The shortness of the course indicates the very elementary treatment of all these topics; but the Meissen school is well attended by the sons of small proprietors, and evidently fulfills a needed function in that portion of the country. There is room for a great many more of the same kind, but the system as a whole is as yet only in its beginnings.

The lowest grade of agricultural schools—distinguished as "land-culture schools" (*ackerbauschulen*), or locally as peasant schools, from the higher grade—are altogether elementary in their teaching, agriculture practice being the main point aimed at, and as such of course adapted to local needs; while on the literary side the grade is that of an American grammar school.

Whether this last grade of schools would be successful in America, where class distinctions are not recognized, I consider very doubtful; but I think some of the methods and subjects of instruction could be very properly and usefully engrafted upon our secondary schools, especially in the rural districts.

There are also some separate "*winter schools*" that give short courses, usually of special instruction on some locally important practical subjects; very much as is done in some of our American agricultural colleges, though here commonly on a higher plane.

The instruction given by *traveling teachers* in the rural districts differs in no essential point from that connected with our Farmers' Institutes; only the more complex government machinery is called into action in connection with the officially recognized agricultural societies, district fairs, and other occasions of public interest, to bring together the audiences. The extent to which this mode of diffusing progressive ideas in agriculture is practiced varies very greatly in different portions of the country, as does also, naturally, the more or less elementary treatment of the subject, according to the degree of advancement of education and agriculture in each district.

The *Agricultural Experiment Stations of Germany*, intimately connected as they are with agricultural progress, are mostly unconnected with educational institutions proper. The latter are, however, throughout more or less engaged in experimental and other original work, which is there expected of every teacher of the higher grades, and to a very large extent forms the gauge of his advancement, and of the estimation in which he is held.

The experiment stations proper are not all organized on a uniform plan or for a uniform purpose; their functions conform in a large degree to local demand and requirements, as a consequence of the fact that many of them are dependent upon the district agricultural societies, from whom they receive a portion of the subsidies granted to these societies by the Government. The analysis of fertilizers forms a large proportion of the work of most of the general stations; and as, strange to say,

there exists no governmental control of the fertilizer trade, this work is of the utmost importance and is, of course, foremost among the services required of the stations by the district societies. Unquestionably, the American system of State experiment stations as part of a great system centering in the Department of Agriculture at Washington, is very far in advance, *as a system*, of the uncertain tenure by which most of the German stations hold their incomes and organization. Practically, however, their work is largely systematized and unified by the existence of the general association of experiment stations (*Verband der Versuchsstationen*), at the annual (migratory) meetings of which the station men come together to compare notes and unify by agreement both methods and subjects of investigation. The comparatively uniform climate of the country embraced by this association renders such agreements much more easy than is the case in a country of the enormous extent of the United States, where climatic, cultural, and commercial conditions are so varied as to render such uniformity both impossible and undesirable. Having had the advantage of being present at, and participating in, one of these annual meetings at Berlin, I was forcibly impressed with this difference as compared with the corresponding meetings of the American Association of Experiment Stations.

Outside of these officially established institutions for instruction, experimentation, and research in agriculture, there is one potent factor through which they are kept in constant touch with the progressive elements of agricultural population. This factor is the Agricultural Association of Germany (*Deutsche Landwirthschaftliche Gesellschaft*), which in a measure corresponds to a "State Agricultural Society" in its functions, since besides the membership fees it receives more or less of government subsidies, mostly for specific purposes. Its meetings are partly migratory, as are, likewise, the general expositions or fairs held under its auspices. There is, however, one central meeting held annually at Berlin, during a week toward the middle of February, which is known as the "great agricultural week," and which is attended not only by members of the society, but is a rallying point for all who desire to discuss agricultural interests. The deliberations and decisions of this week form a not inconsiderable factor in the programme of the year, and have material influence in commercial and political circles. The quasi-official organ of the society is the *Deutsche Landwirthschaftliche Presse*, a semi-weekly paper, standing at the head of popular agricultural journalism in Germany, and the medium of communication and discussion not only between practical agriculturists, but even between scientific investigators whose researches have direct bearing upon practice. The prominence of this paper insures the widest publicity for everything published in its columns, throughout the German-speaking countries.

In further elucidation of the subject, I give below detailed descriptions of a few of the prominent institutions of Germany.

THE AGRICULTURAL COLLEGE* OF PRUSSIA.

Among the agricultural colleges of Germany probably that of Prussia, at Berlin, may be considered the typical and most complete one in its development and final organization.

* Its official designation is "Landwirthschaftliche Hochschule"; literally, "high school," but in German usage signifying an institution of the university grade, and sometimes a university itself.

Its first beginnings date back to the year 1806, when Albrecht Thaer, the "father of rational agriculture in Germany," established the first "academic school of agriculture" in Germany, at Möglin, in the neighborhood of Berlin, under the special patronage of the King of Prussia. When, a few years after, the University of Berlin was established, the agricultural school was transferred to it as a department, Thaer being appointed Professor of Agriculture at the University. But as agricultural science was then in its infancy and Thaer found it necessary to employ, in the main, practical demonstration in his teaching, he subsequently resigned the university professorship and returned to the "model farm" outside of the city. This institution, however, retained its connection with the university and served for the practical studies of those who in the service of the State required a knowledge of agriculture.

With the development of agricultural science during the first half of the century, it soon became apparent that in order that the instruction at Möglin might keep pace with such advances, it would become necessary to restore more intimate connection of agricultural instruction with the university, where ample provision for the study of the fundamental sciences already existed. Formal reports to that effect were made in 1849, but encountered many practical difficulties; until in the early sixties the agricultural institute at Möglin was definitively closed, and an agricultural department was reëstablished at the university.

For some time its development was greatly hampered by lack of room and appropriate buildings, especially for the rapidly accumulating collections, and for the laboratories for advanced students, for which no provision could be made in the university buildings. In 1876 the construction of a large building specially designed for the agricultural department (which was then given the title of "Landwirthschaftliche Hochschule" or agricultural university) was begun, and in 1881 the various branches of instruction and the museum were transferred to the joint occupancy of the new building.

This building is of brick, with stone basement; dimensions, 188 by 240 feet, and three stories high. In its central portion is a quadrangle covered by a glass roof, 147 by 60 feet, "Machinery Hall," which is specially reserved for the display of agricultural implements and machinery, partly "life-size," partly in the form of models. In the latter category there is of plows alone a collection of several hundred numbers. The zoölogical collections, the institute of animal physiology, and administrative offices occupy the rest of the lower floor or basement.

The second floor is also mainly occupied by collections, among which that of vegetable products and models of fruits, flowers, etc., of cultivated plants of the whole world is so extensive that a special guide and catalogue of eighty-four pages has been issued to facilitate its use. It occupies completely one of the longer sides of the building. An extensive collection of soils and soil-forming rocks and minerals of the kingdom occupies one of the ends of the building, while collections illustrating all branches of agricultural production and manufactures, and fresh-water fishes, together with a collection of beautifully constructed models of buildings for all of these purposes and industries, fill the remainder of this floor.

On the third floor are located the greater part of the lecture-rooms,

laboratories, and work-rooms of the professors and assistants. Here are separate laboratories for botany, vegetable and animal physiology, agricultural chemistry, physics, and surveying; together with an extensive library representing all these branches of science.

Attached to this building, but not properly forming a part of it, is a one-story structure, 92 by 30 feet, containing the general chemical laboratory, where the agricultural students can obtain the needful preparation in general and analytical chemistry; also the special laboratory for investigations in the beet-sugar industry. A tall chimney-stack serves for ventilation as well as for fire-flues.

The total cost of the main college building and equipment, exclusive of collections, has been $632,000 up to 1893.

The faculty of the institution consists of fourteen full professors, sixteen regular assistants, and fifteen "privatdocenten" (instructors compensated only by the fees of students) teaching special branches; forty-five in all. The museums of the several departments are under the direct supervision of their respective professors and their assistants, aided by the janitors.

The branches covered severally by the full professorships are the following—each subject being taught with a special view to its bearing on agriculture: Physics; mineralogy, geology, and pedology (soil study); general chemistry; agricultural chemistry; general (structural and physiogical) botany; agricultural or economic botany; practical agriculture (two professors teaching distinct branches); mathematics; surveying; animal physiology; zoölogy; political and economic science.

The assistants in most cases give instruction in subdivisions of the subjects taught by their chiefs. The "privatdocenten," however, teach a number of specialties, the more extended study of which is provided for in separate institutions. Thus it will be noted that veterinary science and forestry are not represented in the above list of subjects; the reason for this is that there exists in the city of Berlin a large special school of veterinary science, located not very far from the agricultural college, but not directly connected with it, though subject to the same governing body, at the head of which stands the Minister of Agriculture. It is at this special school that veterinary surgeons are educated; while merely such general knowledge as every farmer should possess is imparted by the instructor in the agricultural college, whose work is supplemented by a special instructor in horseshoeing. There is an instructor in forestry; but several special forestry schools exist in Prussia, and to these most of the students making forestry their specialty usually go, sometimes after "absolving" their course at the agricultural college. The latter also has an instructor in economic entomology; one for agricultural engineering and buildings; one for agricultural machinery; two for agricultural technology (sugar-making, brewing, wine-making, etc.); a specialist for the anatomy of domestic animals, etc.

Several of the full professors also give instruction in the university; and the terms of all these institutions are arranged to accord with those of the university.

The requirements for admission to the regular course are specified to be those "entitling the applicant to a reduction of the military service from three years to one year"; meaning, in general, that the course in a gymnasium (high school) has been "absolved," so that the student

would be ready to be admitted to the university in such standing as would qualify him for entering the government service thereafter. There are liberal provisions for the admission of special students and of "hospitants" or visitors. Students admitted to the agricultural college are entitled to attend the university lectures and those of the veterinary and technical institutes without special matriculation.

There is no general graduate degree and no particular time is prescribed for the conclusion of the course, which the student may choose from the subjects taught, according to his particular views or requirements. There are, however, special courses, mostly of two years, leading to definite degrees or certificates admitting the holder to government employ in that specialty. Thus there is a definite prescription for land surveyors, which includes a practical course of one year; a geodetic cultural course of four semesters, for agricultural engineers; and several others leading to definite branches of agricultural practice.

A general fee of 100 marks ($25) per semester admits to all the lectures of the college; laboratory fees range from 10 to 20 marks per semester (or twice that for the year's session of two semesters). Remission of fees in certain cases is provided for; there are also three annual prizes of 150 marks for the best theses on each of the three fundamental branches—agriculture proper, the underlying sciences, and agricultural engineering. A "traveling stipend" of 1,500 marks is also allotted to the best student of the year, recommended as such by the faculty. The student thus endowed obligates himself to carry out a tour of observation, within Prussia or elsewhere, for the study of some agricultural specialty, upon which he reports on his return.

An experimental culture-station of about twelve acres, just outside of the city, has been provided by the Government and placed at the disposal of the agricultural college. It is provided with the necessary farm buildings, together with a small but well-equipped brewery, designed for experiment as well as for practical instruction and actual production. This establishment was originally founded under the auspices of a society having for its object the improvement of the brewing industry, together with instruction in the same; hence, one portion of it is run on a commercial basis, striving, however, to produce a typically good beverage and to test and utilize in practice the indications of the experimental work.

Under a somewhat similar arrangement the college superintends and utilizes for instruction and experimentation an "Institute for the fermentation industries and for starch manufacture," originated and maintained at an annual cost of about 250,000 marks ($62,500), by three industrial societies.

Twenty-two instructors and superintendents are employed in these two practical schools, which are numerously attended; 83 students having taken part in the summer semester of 1891, in the brewery course alone, while 56 attended the instruction in distilling and starch manufacture. The director of these institutes is a member of the college faculty.

THE AGRICULTURAL COLLEGE OF BAVARIA.

The agricultural college of Bavaria is not, like that of Prussia, officially connected with the University at Munich, but forms part of the "Technical University" (*Hochschule*) under a governing board distinct

from that of the university proper. This institution comprises very nearly the same courses and subdivisions now forming the "technical colleges" of the University of California, viz.: Civil Engineering, Agricultural Engineering, Architecture, Mechanical Engineering, Chemical Technology, Agriculture in all its branches. As in the case of the "Morrill Act," "other classical and scientific studies" are provided for, partly in the technical university itself, partly by the opening of any of the courses of the Munich University to the students. Several of the professors also belong to both institutions. Oddly enough, the School of Forestry forms an integral part of the old university and is located in the university buildings, and its distinguished director, Professor Ebermayer, gives the special courses on soil chemistry for both institutions. On investigating the cause of the retention of the forestry school with the old university, I learned that forestry being nearly related to the hunters' noble art, was deemed of sufficient dignity to be associated with the literary departments; but the old-school university men and nobles drew the line at that and declined to have the technical institution form a part of the time-honored University of Munich. This is the more curious, as that institution was for many years the headquarters of agricultural chemistry under the influence of Justus von Liebig, and to-day confers the Liebig medal "for services rendered to agriculture."

Although the agricultural college of Bavaria is thus considerably younger in age than that of Prussia, and has not yet succeeded in obtaining the needful new buildings for its better accommodation, it is well equipped and several of its professors have rendered distinguished services to the progress of agriculture.

As in the case of the Prussian college, students of the technical university may attend courses at the University of Munich and at the (here also separate) veterinary college.

The central experiment station of Bavaria forms part of the agricultural college at Munich, and its officers are teachers as well. There is a special department for fermentation industries, in which, as may be supposed, all that has a bearing upon the brewing industry receives particular attention.

THE GERMAN EXPERIMENT STATIONS.

As an exemplification of the organization and mode of work of the German experiment stations, I give the following account, condensed from a detailed report made in 1892 on the Halle station by its distinguished director, Professor Maerker, who may be considered as standing at the head of experiment station work in Germany.

The building, now stated to be far too small for the operations of the station, consists of a main building of three stories, 50 by 100 feet, with an L about 40 by 117 feet. The cost of these was $50,000; inside equipment, $12,500.

The staff of the station consists of the director, assistant director, ten chemists, two botanists, two gardeners, a secretary, an accountant, and five janitors who, apart from the care of the building, do the rough work of the laboratories. There are thus twenty-three persons regularly employed. The demand for work, however, was of late found to be so heavy that it became necessary to refer a part of it to the sub-station at Magdeburg. The main station reports that in 1891 the number of

analyses and other examinations reported upon was 7,311; at Magdeburg sub-station, 2,544; nearly half being analyses of fertilizers and soils.

The total cost of operations in the same year was 65,000 marks, or about $18,250. Of this sum 9,000 marks was supplied directly by the State (Prussia), 3,000 by the provincial treasury, 40,000 from fees for analyses and other examinations, and 13,000 from various sources.

The same remarks regarding the rapidly increasing demand for (mostly chemical) examinations of agricultural materials and products come from many of the twenty-one stations of Prussia. The Bonn station reports for 1893 a total of 5,374 samples sent in for examination, of which 70 per cent were fertilizers and 18 per cent feed stuffs. In 1891, only 3,657 samples were sent in, showing an increase of nearly 50 per cent in two years.

These data, which might be multiplied indefinitely, speak volumes in respect to the great and rapidly increasing appreciation of experiment station work among the practical men interested in agriculture. They are a telling comment upon the cavilers who, in our country, still question the value and need of similar work on the part of the experiment stations. It will be noted that fees are charged for the examinations of fertilizers, which in the majority of our States are made gratuitously (so far as those directly interested are concerned) by the State fertilizer control stations; which may or may not be connected directly with the experiment stations. Here in most cases the expense is defrayed by a license for the sale of the fertilizers, which in the end is of course paid by the users of the latter. But the cost is thus so thinly distributed that it is barely felt, and cannot count in comparison with the benefit derived by the farmers from the State control of this very tricky kind of merchandise. I was struck with the comment made on our practice in this respect by a high official of the Prussian Ministry of Agriculture, to the effect that "the Draconian laws of our States regarding fertilizers seemed somewhat in contradiction to our boasted liberty." My reply was that as with us the public good is the supreme law, the public submits to the needful restrictions of individual liberty, even when these restrictions savor somewhat of paternalism.

Aside, however, from these examinations of samples sent in from outside sources, the German experiment stations pursue steadily the investigation of important questions connected with the theory and practice of agriculture, to the fullest extent that their means permit.

SWITZERLAND.

Since the chief agricultural industry of Switzerland is dairying, its agricultural schools are naturally directed mainly toward the promotion of this branch; and the times and places of giving instruction are in a measure controlled by this consideration.

At the head of technical instruction of all kinds in Switzerland stands the "Polytechnicum" at Zurich; and here also is the general agricultural school of the commonwealth, of university grade. As in Bavaria, the polytechnic school is not officially connected with the university; it is moreover a federal institution, while the university is a cantonal one.

A number of agricultural schools of second and third grade exist in the republic; but a specially prominent feature are the winter schools,

since it is only in winter that those who exercise the dairy industry can ordinarily attend. Such schools are usually located at the cantonal capitals; and their courses begin when the cessation of the influx of tourists sets the population free to think of their own affairs, and the snow drives both the cattle and their attendants from the mountains to the valleys.

Experiment stations also exist in several of the cantons; and one of the culture stations visited by me—on the Rigi Scheideck, at an elevation of nearly 5,000 feet—proved that much yet remains to be done in that line even in so old a country. Potatoes matured, and good crops of rye and several of the hardier pasture grasses grew at this elevation, where a week's snow storm during the month of August is a common experience, as in fact it was in my case. The snow simply bore down the potato vines and grasses, as the temperature hardly fell below the freezing point; and a week after it would have been difficult to tell that anything had happened to interrupt the summer weather. It thus behooves us to test similarly the agricultural capabilities of our higher altitudes; particularly where, as in the Coast Range, the ocean serves to temper the extremes of temperature materially, both in winter and summer. In the Coast Range, Mount Hamilton invites the location of a station corresponding to that on the Rigi.

GENERAL CONCLUSIONS.

Equipment and Attendance.—One point that strikes the American observer most forcibly in these German institutions, is the abundant provision made everywhere for the tangible illustration of whatever is taught. In the building of the agricultural college of Prussia the space occupied by the museums and illustrative collections exceeds considerably that allotted to the direct process of instruction, two out of the three floors being given to collections, while even on the third floor laboratories predominate over lecture-rooms. While this is rather contrary to the traditional ideas of the dreamy, unpractical tendency of the German, it is entirely in accord with the magnificent showing of industrial progress made by Germany at the Columbian World's Fair; and in this connection the fact mentioned above, that industrial societies have actually founded, and are now defraying the expenses of, industrial schools, which they have then placed under the direction of the college of agriculture, is not less significant. It is in line, too, with the employment by the great chemical manufactories, of hundreds of chemists, whose sole duty is to make investigations tending to discover or improve processes for the manufacture of commercially available products. These facts convey lessons needed even in practical and progressive America, where there is still constant cavil anent the propriety of State aid to education above the grammar grade, and where the practical utility of experiment stations is still deemed a debatable question on which demagogues may hope to acquire a cheap popularity by favoring their abolition. In Germany, so far from this, many of the experiment stations, as stated above, have been founded and are now wholly or in part maintained by local or provincial agricultural societies, usually with some aid from the governments, given through these societies. They and the agricultural colleges are the universally recognized leaders of progress in agriculture, and to them all questions arising in practice are referred.

The meager equipment both in the way of illustrative collections and working facilities that exist at most of our agricultural colleges and experiment stations is peculiarly disadvantageous and inappropriate in a country where a demand for instruction of a "practical" character is maintained with such peculiar loudness and persistency. That this scanty equipment stands essentially in the way of the attractiveness of the agricultural courses to students, not to speak of efficient teaching, is too obvious to require extended comment.

This brings up the question of attendance, which is, more or less, a sore point with the university-grade agricultural colleges of the United States. I have repeatedly endeavored by analysis of the courses and occupations pursued by the students of the corresponding German colleges, to obtain figures by which a fair comparison with those attending American colleges could be made. While unsuccessful in obtaining detailed data, for lack of records, the following considerations are of interest in this connection:

The total annual attendance upon the courses of the Agricultural College of Prussia, at Berlin, is about 400. Of these, approximately half belong to the courses of surveying and agricultural engineering. Of the remaining 200 a not inconsiderable proportion are students taking partial courses in agriculture, while properly belonging to the class of "cameralists," that is, young men aiming at government employment in rural districts as clerks, accountants, and judicial, as well as fiscal officers, of whom a certain familiarity with the details of agriculture is required in examination. The rest, say not exceeding 150, are the agricultural students proper of the classes heretofore enumerated, to wit: those aiming to be managers of large estates, whether of the crown or private, partly as employés, partly as the heirs of the proprietors.

It will be noted that this very numerous class of students is directly dependent upon and connected with conditions, industrial and social, but scantily represented in the United States; hence, the contingent so supplied must be deducted from the credit for attendance given the institution; together with that pertaining to the engineering courses, already referred to. We are thus brought to the conclusion that in Europe, as well as in America, the attendance of farmers proper upon the State college of university grade is not at all large, considering the fact that farming without fertilization and rotation, etc., is an unknown quantity in these old countries, and that it is only universal tradition that maintains a fairly remunerative husbandry among the peasantry.

At the agricultural college of Bavaria the classes in agriculture and agricultural chemistry average about 40 only; alongside of these the classes in forestry and engineering average over 100 each.

In the schools of the second grade the roll shows very uniformly the designation of the students' parents as "land-owners" (*gutsbesitzer*), with the obvious implication that their sons will be their successors in the same occupation of a well-to-do farmer.

In view of all these facts I can but repeat my opinion frequently expressed heretofore that so long as our soils remain productive without imperative need of fertilization, rotation, etc., to insure remunerative crops, the attendance at our colleges of bona fide farmers' sons intending to return to the farm will remain comparatively slight; but as soon as the shoe begins to pinch, and intelligent and frugal husbandry

becomes a necessity, our agricultural colleges and schools will receive a correspondingly increased attendance. The beginning of such a movement is already seen in the attendance, as special students, of those often of mature age, who intend to engage in agricultural branches requiring professional information, training for observation, and educated judgment.

GENERAL RETROSPECT.

Reviewing briefly the general aspects of agricultural education in Germany, we find that in all cases there is at the head of the system one or more departments or colleges of university grade, which educate both the teachers for the institutions of the lower grades, and the agricultural experts that are to stand at the head of large estates and thus lead the van of agricultural progress in practice. To me this appears to be a logically necessary function, the very condition precedent of any rational agricultural education whatever. Yet this has been one of the most bitterly contested points in this country, so that in many States the attempt has been to make all agricultural instruction mainly "practical," even when only a single institution could be established on the basis of the available funds. I think experience has shown that this is an error; that instruction of the highest grade for the education of the leaders of progress is the true function of a State college of agriculture. For in almost every case the colleges whose curriculum was organized on the popular "practical" plan, have, in the course of time, been compelled to raise the standards to a higher plane, with an obvious tendency to place them on a university grade. To discuss the propriety or relative advantage of the organic connection of the agricultural college with the literary and scientific university would carry me beyond the limits of this report. But I cannot reconcile myself to the thought of the official and permanent recognition, as a factor in shaping our educational policy, of the snobbishness which looks down upon agriculture as a vocation of inferior degree. It is truly remarkable that in republican America prejudices should be allowed a foothold which even in monarchical Germany dare not show their face. The strong and influential representation of the agricultural element in the German Reichstag stands in marked contrast to the manner in which the farmers' interests are made to take a "back seat" in our legislative assemblies; not so much because farmers are not there, but rather because for lack of training they cannot make themselves felt as against their well-equipped competitors of the politico-legal profession. It is only by a correspondingly thorough training, connected with their own pursuit, that this state of things can be remedied.

It is evident that it will be long before the mass of farmers will take such a higher course of education, even if it were possible to accommodate the rank and file in the State Agricultural College. There are substantially two plans upon which such instruction in the principles of agriculture, as it is possible to impart within the limited time usually at the disposal of farmers' sons, can be imparted. One is the plan adopted by Germany, of separate institutions on a lower plane than the State College, standing substantially in the place of the high school for those who do not desire the latter kind of education. The other is the system adopted by France, of making instruction in agriculture run parallel with the other grades

and subjects of education, throughout the public school course, in rural districts.

The latter plan would in this country encounter almost insuperable difficulties at the present time, in the lack of qualifications for such instruction on the part of common-school teachers, which is not likely to be remedied within any short space of time. Moreover, it is apt to load down too much the already crowded curriculum of the schools, curtailing still further the time for needful general culture. In my view, however, the establishment of a sufficient number of schools corresponding to the second grade of the Prussian system and provided with specially qualified teachers, would be the appropriate course to be pursued in giving a proper and sufficient opportunity for professional education in response to the demand of the progressive portion of the farming population who desire to retain their sons within their own immediate sphere of influence in the rural districts, while still enabling them to avail themselves of the advantages of rational agriculture.

It may be said that this would still further enhance the already heavy burden imposed upon taxpayers for the maintenance of the public schools. To this I reply that it is difficult to imagine a more important duty in the life of parents than the proper education of their children in their life pursuits; and that their duty to them can hardly be considered as fulfilled by the payment of the traditional $10 to $15 per annum "per census child." There are a great number of other subjects of expenditure which they can better afford to cut short; and it is certain that without such additional provision for the better education of the farming population in their pursuit, the State colleges are powerless to bring about the desired result.

The trade schools now being established at many points in the United States, and of which two will belong to San Francisco, while one may be established in close connection with the University, seem to point the way in which the desired solution for the problem of secondary education for the farming population lies. There is, however, one essential difference, inherent in the nature of the case, to wit: that while in trade schools the acquisition of manual dexterity or "handicraft" plays a prominent part, while instruction in principles may be quite simple and rudimentary: in the farmer's pursuit the handicraft is so readily acquired that most boys attain it more or less perfectly on the home farm by daily practice, while the *principles* upon which the operations of the farm must be based to secure the best results are the main thing needful to be acquired in the school, and unfortunately these principles are very complex, and farm practice must be materially modified according to local conditions. Hence it is that "model farms" can rarely represent more than the best local practice, which will mislead the learner when applied elsewhere. This, in a country where the population is so large and varied, and is so continually on the move, renders necessary a higher grade of instruction than that which is given in the second-grade schools of Europe. The growth of such schools must almost necessarily be slow on this account alone; for the teachers qualified for such instruction, embracing both theory and practice in a nutshell, have still to be educated.

While not strictly within the programme of this report, it may not be inappropriate or irrelevant to state my experience in regard to the ideas

entertained concerning this State by those with whom my inquiries brought me in contact. The facts in the premises may be summed up in the statement, that the almost universal impression as to the natural capabilities and social conditions of California were those conveyed in the writings of Mark Twain and Bret Harte, which are very generally known and read. While some few as travelers, geographers, or business men had had occasion to become acquainted with California as it is, yet the statement that it is now preëminently an agricultural State met with considerable incredulity even on the part of university men and high officials who knew a great deal more about Mashonaland and Central Africa than California. Thus it happened that I was repeatedly called upon to deliver lectures on California topics before scientific societies at Berlin; and it was characteristic of the slight interest usually bestowed upon the Pacific Coast, that it was impossible to procure in the city of Berlin any map of this section that could serve for lecture purposes; so that in one case I had to draw one on a blackboard; in another—that of the Geographical Society—a special (rainfall) map was prepared for the purpose, and distributed to the audience, in order to illustrate the paper properly. The printing of this and other lectures in the proceedings of the respective societies was especially opportune, in that it induced a number of persons who intended to visit the Columbian Exposition to extend their travels to this coast; so that I had the pleasure of welcoming to Berkeley during the past season, quite a number of gentlemen who were among my audiences at the Prussian capital.* Among other visitors whose interest had been aroused by the republication in the German language of Bulletin No. 3 of the U. S. Weather Bureau ("On the Relations of Soil to Climate," 1892) were two Hungarian agricultural engineers, who desired to look into the subject of the reclamation of alkali soils to which I had called the attention of the ministry of agriculture of that country, since vast tracts of similar lands exist in the valley of the Theiss. I subsequently received a request from the ministry to forward samples of Californian alkali soils for comparison with those of Hungary; which has since been complied with.

One of the results of these visits has since become apparent in the appearance of a number of reports and articles on the agriculture of Cailfornia and the Pacific Coast at large, which have appeared partly in official form, partly in various periodicals, notably in the *Deutsche Landwirthschaftliche Presse* of Berlin, already mentioned above. Among these an extended series by Professor Backhaus, of the University of Gottingen, deserves special mention for its completeness and fairness.

In Paris the experience of Berlin was repeated, in lectures delivered by request before the Agricultural Society of France, as well as the Société d'Acclimatation at Paris. Besides these lectures, which were

* Among these visitors were the following: Dr. Emil Schmidt, Imperial Councillor of State, Russia; Professor Maercker, Director of the Government Experiment Station at Halle, Germany; Dr. Carl Thiel, Chief of the Department of Agriculture of Prussia and Councillor of State; Dr. Wittmack, Professor of Economic Botany in the Agricultural College of Prussia, Berlin; Dr. Alexander Backhaus, Professor of Agriculture in the University of Gottingen; John Bolle, Director of the South Austrian Experiment Station and President of the Agricultural Society of Austria; Dr. Hans Solereder, of the Botanical Department of the University of Munich; John Telesky, Attaché of the Hungarian Ministry of Finance; Major P. G. Craigie, Director of Statistical Branch, Board of Agriculture, London; M. Henri Vilmorin, Secretary of the Agricultural Society of France; Professor Lunge, of the Polytechnic Institute of Switzerland, Zurich; Dr. Gust. Retzius, Professor of Geology, University of Stockholm; David Golownin, Civil Engineer, St. Petersburg; Louis Landau, Royal Engineers, Hungary.

printed in the transactions of these societies, a French translation of the bulletin on "Climate and Soils" has since been published in "Annales de la Science Agronomique," the official report of experiment station work. Thus our relations, exchanges, and correspondence with agricultural scientific centers abroad have been materially extended; and much valuable material is constantly coming to us that in the ordinary course of events would not have reached us until it was antiquated, if at all.

I may thus hope that even from a purely utilitarian standpoint, my year's vacation has not been without permanent benefit to the State and to the University.

E. W. HILGARD.

JUNE, 1894.

THE WORK OF AMERICAN EXPERIMENT STATIONS.

By E. W. HILGARD.

[This brief statement of views upon some of the features of the work of the American Experiment Stations was originally prepared for "Garden and Forest," and it is reproduced in this place in the hope that it may contribute something to a general understanding of the scope and purposes of station work.—E. W. H.]

The occasional expressions of dissatisfaction with the work of our Experiment Stations are symptoms which it is desirable should be met by a careful diagnosis and rational treatment, to prevent their developing into a form which might bring serious trouble to the system of which as such, we may justly be proud.

For, the organization of the American stations is undoubtedly much better calculated to bring about unity of action and parallel work than is the case in the German stations, so many of which depend for their existence upon the good-will of local societies or communities, to the demands of which they must cater as far as possible. While the latter condition is one that may at the first blush be considered an undesirable handicapping, yet I believe that it has been largely instrumental in bringing about the high usefulness and the esteem in which these stations are held by the agricultural population.

I think, in fact, that not only is this fulfillment of the wishes and the answering of the practical questions of the local agricultural populations a legitimate function, but one of the chief conditions—the *raison d'etre* of their existence in this country at this time. The discussions had in Congress before the enactment of the Hatch bill show clearly that the usefulness of the stations to the population, and not merely the development of agricultural science as such, was the leading argument that carried the bill. It is quite natural, then, that a failure to fulfill the expectations entertained in this respect should lead to unfavorable criticism, which may in the end involve serious danger to the system. That to a great extent such expectations were, and are, unreasonable, and incapable of fulfillment under the circumstances and within the time-limit of the existence of the stations, is quite true; but that fact supplies a major reason for enlisting the interest and the understanding of the farmers most actively in behalf of the station work.

It has been alleged, and somewhat persistently, that such a policy would be unscientific and, as it were, beneath the dignity of the stations. To this allegation I most emphatically demur. We are very far, in this new country, from being in possession of even any considerable portion of all the facts bearing upon the success or failure of agriculture in the several portions of our immense domain. Over a very large portion of this area, the questions that confront the farmer, and therefore the problems that should be solved for him by the experiment stations, are wholly dissimilar from those that form the legitimate subject of investigation

in the Old World. The farmers' successes and failures are largely due to causes entirely different from those to which corresponding phenomena may reasonably be attributed in the Old World, where centuries of experience have established both general and local rules that have advantageously stood in place of scientific guidance before there was a science of agriculture. The station workers should above all things make themselves acquainted with the difficulties actually encountered by farmers, both by inviting their correspondence, and by personal exploration, so far as means will permit. To do this will alone suffice, in most cases, to disarm criticism, especially if the problems presented are then taken hold of by the stations in good faith and with due deference to the facts as they find them. In my personal experience, I have learned to respect greatly the acumen and good sense with which farmers, as a rule, observe the facts subject to their experience; and while they frequently interpret them wrongly as to cause and effect, yet this need not confuse the (presumably) trained observers at the stations. Nor is it true that the gathering-together of these facts and queries is a merely perfunctory amassing of crude material. It will be found on the contrary a most fruitful source of suggestions for purely scientific investigation heretofore neglected, partly because of want of opportunity, within the Old World scope of observation; and new lights are gradually evolved as the facts arrange themselves in connected and logical order. In this respect, our station men enjoy a great privilege as compared with their European colleagues, if they will only recognize it and make use of it. There is so much new, fresh matter within easy grasp, that there is little occasion or excuse for perfunctory trials of newly-named varieties of vegetables, or for emulating the more recondite theoretical researches which the European stations have both the leisure and the opportunities for conducting successfully.

The stations situated west of the Mississippi have as a rule fallen into the general policy of work indicated above, from stress of circumstances; *i. e.*, in consequence of the imperative demands made upon them by the farming population. Then it has sometimes happened that those trained only in the ideas of Europe and of the Atlantic Coast, not appreciating the limitations imposed upon them by the differences of climate and soil, have mistakenly sought to substitute the practices of the old countries to the more laborious investigation of the new field before them, and missing the mark, they have drawn upon the station the condemnation of "practical men."

Such mistakes can hardly be surprising when we consider the history and conditions of the establishment of the stations; and this is the answer I have made to European workers who animadverted upon the small amount of grain in the vast volume of our station literature: "Suppose that thirty-five or forty stations were to-day established in Germany; do you think you could officer them all with experienced men?" The answer invariably has been, "Assuredly not"; generally with the additional remark that it is hard enough to get well-qualified men for all the stations now existing. If such is the fact in Germany, *we* need not feel humiliated if we have not been able to officer all our new stations with men of broad education and possessing the varied scientific and technical qualification required for this work. I think we may consider that we have done well under these conditions; and no doubt much of the "padding" objected to in our station reports would not have been

printed but for the legal requirement that bulletins shall be issued at least once every three months. While this provision is in some respects a salutary one, yet in view of the necessarily long duration of valid experiments in agriculture, it almost necessarily results in the publication of a good deal of matter which might as well not have seen the light at all, or until "it should have been better digested."

There is one point that should be most jealously guarded by our stations and all those interested in the progress of agriculture, namely, the occasional attempts at interference in the staff appointments by political or local influences having no relation whatever to the legitimate work before them. Nothing can be more fatal to the success of that work, and nothing but stout and determined resistance to all such interference based upon "pulls," the spoils system, or any other consideration than that of fitness, should meet such attempts on the part of station men.

There can be no doubt, also, that in order to meet the large demand for properly qualified men at our stations, more special but still broad training in that direction is needed on the part of our young men. For since agricultural science involves the application of almost every branch of natural science, from the fundamental physics to the uttermost confines of biology, the mere specialist in physics or in biology is of but very limited usefulness in station work. The very broadness of view required in it, constitutes one of it chief attractions, but also one of its greatest difficulties.

I.

REPORTS ON GENERAL WORK IN THE AGRICULTURAL LABORATORIES.

ANALYSES OF SOILS, ALKALI AND ALKALI SOILS, WATERS, ROCKS AND MINERALS, FERTILIZERS, GYPSUM, FRUITS AND VEGETABLE PRODUCTS (FOOD MATERIAL, FIGS, ORANGES, LEMONS, PRUNES, APRICOTS, PLUMS, BANANAS, OLIVES, ETC.); DISCUSSION OF THE SAME AND RELATED SUBJECTS.

RECORD AND DISCUSSIONS OF WORK IN THE GENERAL AGRICULTURAL LABORATORIES.

EXAMINATIONS AND ANALYSES OF SOILS, ALKALI, WATERS, FEEDING STUFFS, FRUITS, AND MISCELLANEOUS SUBSTANCES.

I. ANALYSES OF SOILS.

During the period covered in this report there have been more than 175 samples of soils sent in to this Station from parties throughout the State, for examination either as to need of fertilization, fitness for certain crops, or the presence of some cause productive of injury to trees or crops. In the great majority of cases nothing more than a partial analysis was necessary, and acquaintance with the character and composition as well as climatic conditions of the majority of soils of the State enabled us to give the desired information and to offer suggestions as to the capabilities or treatment of the soil in question.

A few chemical analyses of selected soils were made by M. E. Jaffa for purposes of investigation, and these appear in the following pages.

Mechanical analyses of the soil samples sent to the Columbia World's Fair, in Chicago, were made by R. H. Loughridge, and the results are given below. The general table giving these analyses will be found on pages 60 and 76.

A. SIERRA FOOTHILLS.

No. 1645. *Brownish "bedrock" soil* of Sacramento Valley, from the place of R. C. Kell, west of Yuba City, Sutter County. Taken for the Columbian World's Fair exhibit at Chicago. It is a loam of light brownish tint, varying in thickness from 8 to 12 feet, and usually underlaid by gravel. Natural growth, chiefly herbaceous, with scattered white oaks.

No. 1645. *Brownish "Bedrock" Soil, west of Yuba City, Sutter County.*

Coarse materials above 0.5 mm. diameter	1.4
Fine earth	98.6
	100.0

Chemical Analysis of Fine Earth.

Insoluble matter	50.83	67.34
Soluble silica	16.51	
Potash (K_2O)		.74
Soda (Na_2O)		.24
Lime (CaO)		2.06
Magnesia (MgO)		2.13
Br. ox. of manganese (Mn_3O_4)		.02
Peroxide of iron (Fe_2O_3)		8.68
Alumina (Al_2O_3)		11.27
Phosphoric acid (P_2O_5)		.24
Sulphuric acid (SO_3)		.01
Carbonic acid (CO_2)		-----
Water and organic matter		6.98
Total		99.71
Humus		1.28
Ash		.46
Soluble phosphoric acid		.05
Silica		.32

Mechanical Analysis of Fine Earth.

Colloid clay		15.30
Silt	<0.25 mm. hydraulic value	37.02
	0.25 mm.	6.48
	0.5 mm.	10.09
	1.0 mm.	8.15
	2.0 mm.	8.25
Sand	4.0 mm.	5.54
	8.0 mm.	4.74
	16.0 mm.	2.24
	32.0 mm.	.06
	64.0 mm.	.27
Total		98.14
Hygroscopic moisture (absorbed at 15° C.)		5.27
Water capacity		59.90

The soil is composed chiefly of clay and finest silt, which give it a high capacity for holding water. In its chemical composition the soil is above the average of the lands of the foothills in richness; especially in phosphoric acid and lime. Its durability is also assured, because of the large amount of clay present, which acts as a storage reservoir for plant food. Its tilling qualities are excellent, as indicated by the large lime, iron, and humus percentages, which with good drainage tend to keep the clay in a flocculated condition.

No. 863. *Red foothill soil*, from ridges south of Grass Valley, Nevada County, at an elevation of 2,500 feet above the sea. It overlies the ancient auriferous gravel deposits to a depth of 6 to 10 feet. The timber growth consists of spruce, cedar, fir, and different kinds of pine, and some black oak. On wetting, the color darkens and the soil becomes slightly plastic. The soil is described in the Report on the Experiment Stations for 1888–89, and the chemical analysis also given. Its mechanical composition is as follows:

No. 863. *Red Soil, Grass Valley, Nevada County.*

Coarse materials above 0.5 mm. in diameter	5.60
Fine earth	94.40
	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		24.78
Silt	<0.25 mm. hydraulic value	21.99
	0.25 mm.	10.31
	0.5 mm.	2.35
	1.0 mm.	5.81
	2.0 mm.	5.77
Sand	4.0 mm.	7.48
	8.0 mm.	10.65
	16.0 mm.	4.44
	32.0 mm.	2.88
	64.0 mm.	75
		97.21
Hygroscopic moisture (absorbed at 15°)		14.20
Water capacity of soil		53.07
Water capacity of fine earth		53.70

The large amounts of the finest sediment, including the clay, gives to the soil its high moisture and water-capacity percentages. The clay is, according to the chemical analysis, largely composed of aluminic hydrate, for the 36.4 per cent of alumina in the soil would require some 40 of soluble silica to form clay, whereas there is but about 11 per cent, thus leaving fully 20 per cent of alumina in the hydrated state. In its capacity for attracting moisture from the atmosphere this soil stands above all others but one of the State thus far examined, while in the water capacity of its fine earth it stands sixth in the table given elsewhere.

No. 986. *Sandy adobe soil* from University vineyard plot, Cupertino, Santa Clara County. This sample was collected for the Columbian World's Fair. The description and chemical analysis of this soil is given in the Experiment Station Report for 1887. In chemical composition the soil contains large percentages of potash, phosphoric acid, and lime. Its mechanical composition is as follows:

No. 986. *Sandy adobe soil, Cupertino, Santa Clara County.*

Fine gravel above 0.5 mm. diameter	30.3
Fine earth	69.7
	100.0

Mechanical Analysis of Fine Earth.

Colloid clay		20.54
Silt	<0.25 mm. hydraulic value	23.24
	0.25 mm.	4.40
	0.5 mm.	3.89
	1.0 mm.	3.50
	2.0 mm.	4.29
Sand	4.0 mm.	9.29
	8.0 mm.	5.94
	16.0 mm.	4.26
	32.0 mm.	8.19
	64.0 mm.	9.21
		96.75
Hygroscopic moisture		5.14
Water capacity of fine earth		46.60

The chemical analysis shows that the alumina in the above clay is all combined with silica as a true clay, leaving none of the hydrate which forms so large an element in No. 863. Both hygroscopic moisture and water capacity are far below the latter, though mechanically the two soils are very similar. The results point very conclusively to the fact that while the fine material in a soil does have its influence on the moisture and water capacities, yet the nature of the soluble portion exerts by far the greatest effect. And of the latter, the hydrates of alumina and iron are preëminent. Practically this soil rates as a clay loam.

Additional Soils Sent for Partial Examination.

Name.	Locality.	County.	Sender.
Gravelly soil	Oroville	Butte	R. M. Price.
Red clay soil	Oroville	Butte	R. M. Price.
Soil and subsoil	Colfax	Placer	W. A. J. Edinger.
Calcareous silty soil	Amedee	Lassen	J. N. Leefeld.
Red soil, subsoil, and underclay	4 miles east of Placerville	El Dorado	S. L. Turner.
Red soil, subsoil, underclay	Dolde	Shasta	E. D. Rathbun.
Red loam soils	5 and 12 miles east Marysville	Yuba	T. W. Harney.
Red soil, subsoil	Diamond Springs	El Dorado	J. P. Dunlap.
Deep red soil	Diamond Springs	El Dorado	J. P. Dunlap.
Sediment soil	Jackson	Amador	H. D. Emerson.

B. GREAT VALLEY.

Alluvial soils of Sacramento River, from peach and cherry orchards of D. D. Gammon, Courtland, Sacramento County. An air-dried portion of each soil was leached and the liquid examined, with the following result:

	Peach Orchard.	Cherry Orchard.
Per cent of matter soluble in water	.112	.091
Again soluble in water after evaporation	.046	.028
Insoluble in water after evaporation	.012	.018
Organic matter	.054	.045
Percentage Composition of the Soluble Matter.		
Sodium carbonate	23.64	19.78
Sodium chloride	5.81 } 40.62	6.97 } 30.77
Sodium sulphate	11.17	4.02
Calcium and magnesium salts	11.16	20.33
Organic matter	48.22	48.90
	100.00	100.00

The alkali in these two soils, while quite "black" from the presence of carbonate of soda, is fortunately not in amounts sufficient to produce any prominent injury to the trees. The use of gypsum on the soil will readily prevent any possible damage. There is a good percentage of phosphoric acid in each soil.

No. 1636. *Reddish soil*, from Manton, Tehama County; sent by M. W. Woodward. It represents a district fifteen miles square, which is being rapidly planted in fruit trees.

No. 1636. *Reddish Soil from Manton, Tehama County.*

Coarse materials>0.5 mm	12.00
Fine earth	88.00
	100.00
Analysis of Fine Earth.	
Insoluble matter 15.67 }	40.79
Soluble silica 25.12 }	
Potash (K_2O)	.50
Soda (Na_2O)	.26
Lime (CaO)	.81
Magnesia (MgO)	1.14
Br. ox. of manganese (Mn_3O_4)	.05
Peroxide of iron (Fe_2O_3)	18.20
Alumina (Al_2O_3)	24.10
Phosphoric acid (P_2O_5)	.26
Sulphuric acid (SO_3)	.04
Carbonic acid (CO_2)	
Water and organic matter	13.56
Total	99.71
Humus	2.00
Ash	.61
Soluble phosphoric acid	.09
Silica	.25
Hygroscopic moisture (absorbed at 15° C.)	11.92

This soil is remarkable for its large amount of soluble matter, and especially of soluble silicates (probably 60 per cent). Its phosphoric acid is also unusually high, its potash and lime fair, and its humus large.

Nos. 1698, 1699. *Reddish soils* from Natoma vineyard, Natoma, Sacramento County; sent by the Natoma Vineyard Company, for analysis. They are from different parts of the tract:

	No. 1698.	No. 1699.
Coarse materials above 0.5 mm. diameter	5.00	19.00
Fine earth	95.00	81.00
	100.00	100.00
Analysis of Fine Earth.		
Insoluble matter	76.30	76.53
Soluble silica	3.13	4.13
	79.43	80.66
Potash (K_2O)	.49	.62
Soda (Na_2O)	.29	.14
Lime (CaO)	1.45	1.55
Magnesia (MgO)	.94	.94
Br. ox. of manganese (Mn_3O_4)	.03	.06
Peroxide of iron (Fe_2O_3)	6.87	8.78
Alumina (Al_2O_3)	6.25	3.21
Phosphoric acid (P_2O_5)	.20	.11
Sulphuric acid (SO_3)	.28	.10
Carbonic acid (CO_2)		
Water and organic matter	3.34	4.81
Total	99.57	100.88
Humus	.89	1.06
Ash	1.73	1.48
Soluble phosphoric acid	.05	.09
Silica	.93	.47
Hygroscopic moisture (absorbed at 15° C.)	7.10	4.78

Both of the above soils are rich in lime, potash, and phosphoric acid; the latter, especially in the soil No. 1698, being above the average in California soils.

No. 1055. *Red sandy loam soil* of Fresno Plains, Sec. 9, T. 14 S., R. 19 E., 9 miles west of Fresno; from M. T. Kearney's "Fruitvale" tract. Taken to a depth of 24 inches. Its description and chemical analysis are found on page 29, Report for 1890. This sample was taken for the World's Fair, and its mechanical analysis resulted as follows:

Coarse materials above 0.5 mm. diameter	9.00
Fine earth	91.00
	100.00
Mechanical Analysis of Fine Earth.	
Colloid clay	11.01
Silt: <0.25 mm. hydraulic value	17.17
Silt: 0.25 mm.	1.70
Silt: 0.5 mm.	6.48
Silt: 1.0 mm.	8.49
Silt: 2.0 mm.	12.69
Sand: 4.0 mm.	18.16
Sand: 8.0 mm.	15.41
Sand: 16.0 mm.	3.35
Sand: 32.0 mm.	5.41
Sand: 64.0 mm.	.21
	100.08
Hygroscopic moisture (absorbed at 15° C.)	3.62
Water capacity of soil	35.40
Water capacity of fine earth	42.20

The soil contains visible white specks of potash feldspar: black and golden mica and quartz. Its color is reddish-brown when moist, and grayish-brown when dry; can be tilled at all times.

The chemical analysis shows that the 6 per cent of alumina present is probably all combined with the soluble silica to form true clay, and the hygroscopic moisture and water capacity is due chiefly to the fine earth present. The latter is about an average for sandy land.

No. 1678. *Alkali silt soil*, from the Culture Experiment Station, Tulare; this is from a large sample taken for purposes of chemical and physical tests in the solution of the alkali problem.

As received, it formed large chunks or clods, representing the hardpan into which black or carbonated alkali transforms any soil containing sufficient clay to give it cohesion. It is mouse-gray in color.

On wetting the *dry* mass it softens quickly, although while moist in the clod water fails to penetrate it. In leaching out the alkali it is necessary to operate somewhat quickly, as in the course of longer time it settles down into a compact mass almost impervious to water. It was leached prior to the mechanical analysis, which resulted as follows:

No. 1678. *Alkali Silt Soil, Tulare Experiment Station.—Mechanical Analysis of Fine Earth.*

Colloid clay		10.42
Silt	<0.25 mm. hydraulic value	21.75
	0.25 mm.	3.06
	0.5 mm.	2.82
	1.0 mm.	6.49
	2.0 mm.	7.65
Sand	4.0 mm.	10.19
	8.0 mm.	13.54
	16.0 mm.	5.28
	32.0 mm.	10.53
	64.0 mm.	2.08
		93.81
Hygroscopic moisture (absorbed at 15° C.)		6.41

According to this analysis this is a sandy or silty loam, which should till readily at all times, as is actually the case where it is not contaminated with black alkali. But where that alkali is present to any large extent it stubbornly resists the plow so that the pick and crowbar must be used to loosen it.

No. 1466. *Soil* from Miramonte, Kern County, Sec. 17, T. 26 S., R. 23 E.; sent by G. A. Raymond, Rancho Palma. "The sample is taken from the fig orchard, and represents a large streak running from southeast to northwest, and probably covers 200 acres in this section. Everything does well in this soil, even when it is new and without previous cultivation. The growth of trees on it last spring (1890) was immense. On it are fig trees (White Adriatic), now in their third year from the nursery, with trunks 4 to 6 inches in diameter, with corresponding tops. They have made a heavy growth this year, though setting but little fruit. The soil bakes hard when flooded. It is tillable when moist."

No. 1466. *Fig Soil from Miramonte, Kern County.*

Coarse materials>0.5 mm.		1.00
Fine earth		99.00
		100.00

Analysis of Fine Earth.

Insoluble matter	61.93	76.81
Soluble silica	14.88	
Potash (K_2O)		1.04
Soda (Na_2O)		.29
Lime (CaO)		1.29
Magnesia (MgO)		1.24

Br. ox. of manganese (Mn_3O_4)	.13
Peroxide of iron (Fe_2O_3)	6.27
Alumina (Al_2O_3)	8.29
Phosphoric acid (P_2O_5)	.22
Sulphuric acid (SO_3)	.04
Carbonic acid (CO_2)	-----
Water and organic matter	4.03
Total	99.65
Humus	.60
Ash	.28
Soluble phosphoric acid	.04
Silica	.22
Hygroscopic moisture (absorbed at 15° C.)	4.80

The soil is very rich in all that pertains to plant food except humus, the nitrogen-supplying ingredient, which is, however, in fair supply.

Additional Soils Sent for Partial Examination.

Name.	Locality.	County.	Sender.
Sacramento Valley.			
Tule soil	Dutton's Landing	Solano	J. W. Dutton.
Calcareous loam of Indian mound	Yolo Orchard	Yolo	E. C. Zane.
Sac'to alluvium (2)	Sacramento	Sacramento	C. H. Bentley.
San Joaquin Valley.			
Gray sandy soil	8 miles s.w. of Mendota	Fresno	Philip Douglass.
Soils and subsoils (4)	Sunnyside	Fresno	John Darling.
Sandy soil and subsoil	Fresno	Fresno	Kern County Land Co.
Red sandy soil and subsoil	Fresno	Fresno	A. E. Smith.
Calcareous hardpan	Fresno	Fresno	A. E. Smith.
Sandy loam	Fresno	Fresno	F. J. Laird.
Black alkali soil	Fresno	Fresno	F. J. Laird.
Dark loam	Fresno	Fresno	F. J. Laird.
Dark loams (soil and subsoil)	Oleander	Fresno	R. C. Sloan.
Sandy soil	Fresno	Fresno	Fowler & Smith.
Sandy soil	Fresno	Fresno	J. S. Dore.
Sandy soil	Fresno	Fresno	J. S. Dore.
Soils (3)	Kern City	Kern	Miss S. M. Thompson.
Yellow loam soils (3)	Firebaugh	Fresno	A. C. Vandivier.
Sandy soil and subsoil	White's Bridge	Fresno	P. Dengler.
Soil	O'Neals	Madera	J. H. Oester.
Reddish subsoil	O'Neals	Madera	J. H. Oester.
Alluvial loam soil	Tulare	Tulare	W. C. Imp. Co.
Silty alkali soils (1, 2, and 3 feet)	1 mile south of Pixley	Tulare	E. S. Colburn.
Coarse sandy soils (1, 2, and 3 feet)	1 mile south of Pixley	Tulare	E. S. Colburn.
Dark gray sandy loam	1 mile south of Pixley	Tulare	E. S. Colburn.
Reddish sandy loam	Dinuba	Tulare	A. Sharman.
Light sandy loam	Dinuba	Tulare	A. Sharman.
Chocolate soil	Lerdo	Kern	W. T. Armstrong.
Calcareous hardpan	Lerdo	Kern	W. T. Armstrong.
Soil, subsoil, and clay		Merced	Charles Welch.
Sandy loams (2)	Dos Palos	Merced	E. E. Smith.
Black abode soils (2)	Dos Palos	Merced	E. E. Smith.
Loam soils (4)	Near Dos Palos	Merced	William Hatteroth.
Sandy soil	Farmington	San Joaquin	L. Weitz.

C. COAST RANGE.

No. 1647. *Redwood soil*, from the land of Colonel J. B. Armstrong, Guerneville, Sonoma County. Collected for the Columbian Exhibition by Colonel Armstrong. The soil has a heavy redwood forest growth and is but little cultivated, though highly productive of grapes and deciduous fruits.

No. 1647. *Redwood Soil, Guerneville, Sonoma County.—Analysis of Fine Earth.*

Chemical Analysis.

Insoluble matter	65.47	75.33
Soluble silica	9.86	
Potash (K_2O)		.99
Soda (Na_2O)		.16
Lime (CaO)		.90
Magnesia (MgO)		1.97
Br. ox. of manganese (Mn_3O_4)		.03
Peroxide of iron (Fe_2O_3)		5.77
Alumina (Al_2O_3)		7.69
Phosphoric acid (P_2O_5)		.16
Sulphuric acid (SO_3)		.02
Carbonic acid (CO_2)		.....
Water and organic matter		6.50
Total		99.52
Humus		.62
Ash		.27
Soluble phosphoric acid		.06
Silica		.10

Mechanical Analysis.

Colloid clay			16.54
Silt	<.25	mm. hydraulic value	16.86
	.25	mm.	3.57
	.5	mm.	3.44
	1.0	mm.	4.09
	2.0	mm.	7.21
Sand	4.0	mm.	9.82
	8.0	mm.	13.35
	16.0	mm.	7.93
	32.0	mm.	9.04
	64.0	mm.	5.75
			96.90
Hygroscopic moisture (absorbed at 15° C.)			5.14
Water capacity			52.30

This is a first-class soil, and highly productive when planted in grapes and deciduous fruits. Its percentage of potash is very high, its phosphoric acid good, and its lime fair. There is less humus than might be expected from a forest soil. Its water capacity is remarkably high.

Soils of Alexander Valley, 5 miles east of Healdsburg, Sonoma County; sent by Alex J. Young, San Francisco.

No. 1. "Soil of bottom land from flats bordering the creek. Depth of soil unknown, but not less than 10 feet. Water is found in wells dug on this land, at a depth of 25 feet during summer months. The land is well protected from winds, except from the south. The temperature in summer is often high, with occasional fogs; in winter it is subject to somewhat severe frosts."

The soil is a loam, dark from organic matter, which, when burnt off, leaves the soil reddish in color, similar to that of the hills. It is gravelly, but with water is plastic. The percentage of phosphoric acid is very low.

No. 2. "Dark red soil taken from an elevated plateau about 125 feet above the creek. The land is at present uncleared, and is covered with a heavy growth of manzanita, madrone, white and black oaks, and fir trees. The situation is somewhat exposed, but less subject to frosts than the bottom lands. The depth of the soil is unknown, but at four feet the soil is identical with that of the surface."

The soil is rather stiff, its lumps not yielding very readily to water. The percentage of phosphoric acid is low.

No. 1655. *Red vineyard soil* of Napa Valley, from the vineyard of H. W. Crabb, 3 miles east of Oakville and 1 mile from hills, Napa County. Vegetation originally white or "foothill" oaks. The soil is a reddish-gray loam, containing considerable angular gravel.

The following shows the chemical composition of the soil taken to a depth of 10 inches:

No. 1655. *Crabb's Red Vineyard Soil, Oakville, Napa County.*

Coarse materials >0.5 mm.	24.85
Fine earth	75.15
	100.00

Chemical Analysis of Fine Earth.

Insoluble matter	64.33	73.03
Soluble silica	8.70	
Potash (K_2O)		1.28
Soda (Na_2O)		.26
Lime (CaO)		.54
Magnesia (MgO)		.91
Br. ox. of manganese (Mn_3O_4)		.03
Peroxide of iron (Fe_2O_3)		7.70
Alumina (Al_2O_3)		8.79
Phosphoric acid (P_2O_5)		.09
Sulphuric acid (SO_3)		.01
Carbonic acid (CO_2)		----
Water and organic matter		7.11
Total		99.75
Humus		1.05
Ash		.66
Soluble phosphoric acid		.04
Silica		.36

Mechanical Analysis.

Colloid clay		21.73
Silt	<.25 mm. hydraulic value	31.64
	.25 mm.	5.10
	.5 mm.	4.95
	1.0 mm.	5.47
	2.0 mm.	6.22
Sand	4.0 mm.	4.63
	8.0 mm.	2.94
	16.0 mm.	3.36
	32.0 mm.	4.12
	64.0 mm.	6.56
		96.72
Hygroscopic moisture (absorbed at 15° C.)		4.25
Water capacity		47.40

The above analysis marks the soil as very high in potash and medium in lime and phosphoric acid, indicating a probable need of the latter in a few years. It is composed very largely of clay and finest silt, which give a high power for holding water, but it is very low in hygroscopic moisture.

No. 1679. *Black adobe soil*, from the University grounds, Berkeley, Alameda County. The sample was taken for the Columbian World's Fair, to the depth of 3 feet, and a large quantity was also well mixed and stored for special investigations. The chemical and mechanical analyses of the samples so obtained resulted as follows:

No. 1679. *Adobe Soil from University Grounds, Berkeley.*

Coarse materials above 0.5 mm. in diameter	15.00
Fine earth	85.00
	100.00

Analysis of Fine Earth.

Insoluble matter	54.50	73.50
Soluble silica	19.00	
Potash (K_2O)		.73
Soda (Na_2O)		.20
Lime (CaO)		1.15
Magnesia (MgO)		1.08
Br. ox. of manganese (Mn_3O_4)		.04
Peroxide of iron (Fe_2O_3)		8.43
Alumina (Al_2O_3)		7.92
Phosphoric acid (P_2O_5)		.19
Sulphuric acid (SO_3)		.04
Carbonic acid (CO_2)		----
Water and organic matter		6.54
Total		99.82
Humus		1.21
Ash		.94
Soluble phosphoric acid		.04
Soluble silica		.69

Mechanical Analysis of Fine Earth.

Colloid clay		44.27
Silt	<.25 mm. hydraulic value	22.70
	.25 mm.	2.65
	.5 mm.	3.57
	1.0 mm.	4.48
	2.0 mm.	5.42
Sand	4.0 mm.	6.72
	8.0 mm.	3.97
	16.0 mm.	1.33
	32.0 mm.	.92
	64.0 mm.	.43
		95.46
Hygroscopic moisture (absorbed at 15° C.)		11.98
Water capacity		50.40

On comparing the above with previous analyses of adobe soils from near the same locality taken to one foot depth only, we find one third more clay, while the amount of fine silt is almost the same in all. There are also differences in the amounts of coarser materials.

The percentages of potash and lime are much greater in this sample, while that of phosphoric acid is about an average of the analyses previously made. The humus content is materially much less (about one half) in this 3-foot sample than in the surface soil of 12 inches depth formerly analyzed.

Soils, subsoils, etc., from Soquel Valley, Santa Cruz County; sent by Mrs. M. N. Clark and Marston Niles of Santa Cruz. The valley lies along Soquel Creek, which flows southward into Monterey Bay.

"The ranch from which the soils were taken is three miles from the bay. Here the valley is one third of a mile wide, and on each side is bounded by hills about 200 feet high. The slope on the east, near which the creek flows, is very steep and well timbered with oak and redwood; the hills on the west are much less abrupt, and chiefly pasture lands, and only in the gulches have redwood growth. This side (on which the ranch is located) slopes gently to the creek, in places falling off suddenly into successive low terraces. The valley continues southward for about two miles toward the bay, when the side-hills sink down and the valley presents a plateau of about 80 feet in height, thence to the bay. To the northward the valley continues some miles with about the same width, and then the land rises into what is known as 'Highland' and 'Skyland' of the Santa Cruz Mountains."

Five samples of soil, with their respective subsoils, underclays, etc., to depths of several feet, in all about thirty specimens, were taken and sent as representative of the tract. Two typical soils are presented in this collection—a grayish sandy soil of the lower portion of the valley, and a black "redwood soil" of the higher, at an elevation of about 50 feet above the creek. The soils are deep, and no change occurs in tint at a less depth than 12 inches, and in some cases several feet. Both soils are poor in phosphoric acid, and require of course the application of superphosphates or bone-meal, for full productiveness.

No. 1693. *Dark soil*, from Paso Robles, San Luis Obispo County; sent by Van R. Elliott. The samples are from the first bench west of the Salinas River, in the town of Paso Robles. The soil is 12 or 14 feet deep, underlaid by 5 feet of sand and 4 inches of cemented, round bowlders. The analysis was made by Marvin Curtis, laboratory assistant.

No. 1693. *Soil from Paso Robles, San Luis Obispo County.*

Coarse materials >0.5 mm	55.00
Fine earth	45.00
	100.00

Analysis of Fine Earth.

Insoluble matter	74.58	86.30
Soluble silica	11.72	
Potash (K_2O)		.51
Soda (Na_2O)		.08
Lime (CaO)		1.04
Magnesia (MgO)		.34
Br. ox. of manganese (Mn_3O_4)		.01
Peroxide of iron (Fe_2O_3)		3.06
Alumina (Al_2O_3)		3.20
Phosphoric acid (P_2O_5)		.29

Sulphuric acid (SO_3)	.06
Carbonic acid (CO_2)	----
Water and organic matter	4.92
Total	99.81
Humus	1.85
Ash	1.18
Soluble phosphoric acid	.025
Silica	.90
Hygroscopic moisture (absorbed at 15° C.)	7.60

The soil is thus shown to be fairly supplied with potash and rich in phosphoric acid, with a fair amount of lime. Its hygroscopic power is high for so sandy a soil, and is probably due to the large amount of soluble silicates.

Soils from Cholame Valley and table land 22 miles northeast of San Miguel, Sec. 14, T. 23 S., R. 14 E.; sent by C. Salomonson, of Berkeley.

"The valley lies between San Joaquin Valley on the east and San Miguel. The atmosphere is clear and without fogs. The temperature does not exceed 108.7° in summer; while in the winter months there are some years when in January or February water contained in vessels freezes. Snow very seldom falls in the valley, while of rain there is usually an average of 16 inches. Prunes grow well in the valley soil, producing fruit of first quality. On this soil oak trees also grow very rank. On the table land bordering the valley, at an elevation of 50 feet above it, there is a growth of chaparral, pine, and oak, the latter two becoming large and firm."

The specimen of *valley soil* taken to 12 inches below the surface is a dark loam, which, kneaded with water, becomes slightly plastic. It contains a fair amount of lime and phosphoric acid. With good depth and proper irrigation the soil should produce abundantly both fruits and grain.

The samples of soil from the adjoining table lands comprise three varieties: a light calcareous loam, with a fair amount of phosphates but with little humus; a reddish-brown clay, not calcareous but stiff and tenacious, not easily crushed between the fingers when dry, though yielding readily to water, and containing a fair amount of lime and phosphates; and a dark calcareous clayey loam, quite tenacious when wet, and containing more phosphates than the other samples.

The following description of the Cholame Valley is from Mr. J. V. Webster, former Patron of the Experiment Station at Paso Robles: "That portion of the valley above the mouth of Cholame River and on either side of the San Juan Creek varies from one half to a mile in width between the hills, which are more rugged and precipitous than on the Estrella Plains. The soil varies greatly and much of it is dry and gravelly, very little being adapted to safe or successful cultivation. There is no timber save a few scrub-oak and some willow along the creek. The soil is not as good as the average of the Estrella or Carisa Plains."

Additional Soils Sent for Partial Examination.

Soil.	Locality.	County.	Sender.
Soil	Bridgeville	Humboldt	E. C. Mason.
Yellow loam soil, subsoil	Eureka	Humboldt	Fruitland Ra'ch.
Dark "prairie" loams (2)	Happy Valley	Humboldt	M. R. Jager.
White pasture soil		Lake	A. Beverly.
Red hill soil			
Dark chocolate valley soil	Dry Creek Valley, near Healdsburg	Sonoma	C. W. Keys
Dark loam hillside soil			
Red clay subsoil			
Hillside soil and subsoil			
Soil and subsoil	Los Guilicos	Sonoma	S. A. Karns.
Soil and subsoil			Ed. Anderson.
Dark loam soil	Alexander Valley	Sonoma	Alex. J. Young.
Deep red plateau soil			
Red gravelly clay soil and subsoil	Glen Ellen	Sonoma	Mrs. O. Gordenker.
Stiff foothill clay soil and subsoil			
Stiff clay soil and subsoil			
Red mountain soil[a]	Napa	Napa	E. P. Blagrove.
Red mountain subsoil[b]			
Clay soil, subsoil	Rancho del Valle	Alameda	A. G. Platt.
Clay soil			
Clay adobe			
Black adobe	San Leandro	Alameda	E. Musson.
Dark red hill soil			
Black adobe		Santa Clara	Mrs. E. N. Fuller.
Dark adobe soil[c]	Evergreen	Santa Clara	W. H. Robinson.
Light soil[d]			
Soil[e]	Watsonville	Santa Cruz	C. H. Rogers.
Dark clay soil, subsoil	Campbell Station	Santa Clara	E. C. Armstrong.
Soil[f]	Near San José	Santa Clara	Geo. Goodacre.
Subsoil[g]			
Adobe soils (3)	San José	Santa Clara	E. Geisel.
Red loam soil	Los Gatos	Santa Clara	B. L. Bartlett.
Gravelly clay subsoil			
Reddish loam soil			
Red clay subsoil			
Dark loam soil and subsoil			
Dark sandy hillside loam	Cayucos	S. Luis Obispo	Rev. S. Slocombe.
Light sandy soil			
Soil	Paso Robles	S. Luis Obispo	V. R. Elliot.
Soil	Santa Barbara	Santa Barbara	P. Rice.
Soil	Carpenteria	Santa Barbara	C. Lillingston.
Dark loam soil	Santa Barbara	Santa Barbara	J. J. Perkins.
Soils and subsoils (7)	Piru Ranch	Ventura	Leslie F. Gay.
Light sandy loams (5)	Santa Maria	Santa Barbara	T. N. Warner.

[a]The red mountain soil contains .106 per cent of lime and .112 per cent of phosphoric acid.
[b]The subsoil contains .154 per cent of lime and .123 per cent of phosphoric acid.
[c]The dark adobe soil contains .70 per cent of lime and .43 per cent of phosphoric acid.
[d]The light soil contains .52 per cent of lime and .27 per cent of phosphoric acid.
[e]The soil contains .18 per cent of phosphoric acid.
[f]The soil contains .99 per cent of lime and .05 per cent of phosphoric acid.
[g]The sub-soil contains 1.93 per cent of lime and .15 per cent of phosphoric acid.

D. SOUTH CALIFORNIA.

No. 1284. *"Adobe" soil* from the moist lands bordering Chino Creek, South California Experiment Station, near Pomona. A mouse-colored, moderately heavy loam, somewhat silty; the dry lumps crush quite readily between the fingers, and show little or no grit. With acid there is effervescence because of the presence of carbonate of lime; on wetting, the color deepens considerably, and when kneaded the soil

becomes quite adhesive, showing that it must not be tilled while wet. The chemical analysis is given on page 38 of the Report for 1890, and shows large potash, phosphoric acid, and lime percentages; the alumina is probably all in combination as true clay. The following is the mechanical analysis of this soil:

No. 1284. *"Moist Adobe" Soil, Experiment Station, near Pomona.*

Coarse materials above 0.6 mm. in diameter	10.00
Fine earth	90.00
	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		13.44
Silt	<0.25 mm. hydraulic value	20.65
	0.25 mm.	1.37
	0.5 mm.	4.91
	1.0 mm.	5.95
	2.0 mm.	13.46
Sand	4.0 mm.	10.36
	8.0 mm.	9.25
	16.0 mm.	12.01
	32.0 mm.	2.75
	64.0 mm.	1.66
		95.81
Hygroscopic moisture (absorbed at 15° C.)		5.98
Water capacity		60.20

In this soil we have somewhat of an anomaly in a rather low power for absorbing moisture in a saturated atmosphere at a low temperature, and a high capacity for holding water. That the former may be due to the absence of aluminic hydrate (the alumina being in the form of clay, as shown in the chemical analysis) can be readily supposed; but why the water capacity should be so high with but 44 per cent of clay and fine silt is not clear.

No. 1663. *Red mesa soil*, from the home place of A. J. Twogood, in the center of the town of Riverside, and from the first orange orchard planted in that region. It represents a medium between the heavy and light orange lands. The specimen was taken by J. C. Cutter.

No. 1663. *Red Mesa Soil, Riverside.*

Coarse materials above 0.5 mm. diameter	4.00
Fine earth	96.00
Total	100.00

Mechanical Analysis of Fine Earth.

Colloid clay		19.37
Silt	<0.25 mm. hydraulic value	12.20
	0.25 mm.	5.63
	0.5 mm.	4.22
	1.0 mm.	12.19
	2.0 mm.	18.52
Sand	4.0 mm.	17.90
	8.0 mm.	6.92
	16.0 mm.	.52
	32.0 mm.	.11
	64.0 mm.	.12
		97.70
Hygroscopic moisture		5.06
Water capacity		53.20

This soil is rich in clay and silt, while its sand is of the finest grades, thus giving to it a high capacity for holding water. Its hygroscopic power is, on the contrary, quite low.

No. 1281. *Reddish-gray sandy loam* of the South California Experiment Station, near Pomona. The soil when wet darkens a little and becomes slightly plastic, but not adhesive. The soil is described in the Experiment Station Report for 1890–91, and its chemical analysis given. Its main chemical features are high percentages of potash, phosphoric acid, and lime, thus indicating high fertility under proper physical conditions.

The following is the result of the mechanical analysis:

No. 1281. *Reddish Mesa Soil, South California Experiment Station.*

Coarse materials above 0.5 mm. in diameter		10.00
Fine earth		90.00
		100.00
Mechanical Analysis of Fine Earth.		
Colloid clay		7.60
Silt	<0.25 mm. hydraulic value	15.52
	0.25 mm.	3.01
	0.5 mm.	5.49
	1.0 mm.	3.92
	2.0 mm.	6.40
Sand	4.0 mm.	7.92
	8.0 mm.	11.87
	16.0 mm.	16.36
	32.0 mm.	14.65
	64.0 mm.	5.10
		97.84
Hygroscopic moisture (absorbed at 15° C.)		1.98
Water capacity of fine earth		44.70

The soil is low in both hygroscopic power and water capacity, when we compare it to soils that reach 14 of the former and 60 to 80 of the latter. For so sandy a soil it, however, has fair percentages of both of these. Its chemical analysis indicates that all of its alumina is in the form of true clay, otherwise the moisture and water coefficients would probably be higher.

Soil from Redlands, San Bernardino County; taken from the Lugonia ridge, a low elevation in the northern part of the town; sent by John W. Pears. It is fawn-colored, coarsely sandy, granitic in character.

"The soil is apparently the same in character for the three feet represented by soil and subsoil; and the same has been observed at a depth of 10 or 15 feet below the surface. The soils of the Lugonia region vary considerably in character, some being much lighter and sandier than others. To the southward they become heavier, until at about a mile from where the samples were taken they pass into the red lands of the valley. This sandy soil absorbs a great deal of water, and more water has to be used than on the red lands. Manure put on it, unless thoroughly rotted and pulverized, will lie for a long time unchanged."

The above soil is very sandy in nature and contains scarcely any clay, which accounts for the rapid leaching complained of. It is evidently from one of the cienega debris ridges described by Professor Hilgard in an article on "The Cienegas of Southern California" in this report.

Soils from tract of the Manzana Colony, situated on the northern slope of the La Lieber range of mountains, west end of Antelope Valley, Los Angeles County; sent by T. W. Haskins.

Sandy soil and subsoil	Etiwanda	San Bernardino	C. Newton Ross.
Reddish loam	Etiwanda	San Bernardino	C. Newton Ross.
Soil	Antelope Valley	Los Angeles	L. T. Rogers.
Alluvial loams (2)	Rivera	Los Angeles	W. J. Wedemyer.
Alkali soil and crust	Antelope Valley	Los Angeles	P. B. Mathiason.
Red sandy loam and subsoil	Point Loma	San Diego	H. Metcalf.
Red soil and subsoil	Chula Vista	San Diego	F. W. Reid.
Dark calcarous loam soils (2)	Otay Mesa	San Diego	H. M. Fortesque.
Gray soil	Otay Mesa	San Diego	H. M. Fortesque.
Dark clay soil	Otay Mesa	San Diego	H. M. Fortesque.
Stiff clay soil	Otay Mesa	San Diego	H. M. Fortesque.
Loam soils (3)	El Toro	Orange	E. Petrie Hoyle.

[a] It contains 0.3 per cent of phosphoric acid.

THE DIGESTION OF SOILS FOR ANALYSIS.

By E. W. Hilgard and M. E. Jaffa.

Of late years the propriety of preparing the soil extract for general analysis by digestion in beakers covered with a watch glass, as mostly practiced heretofore, has been called in question; chiefly on the ground that under such conditions the chlorhydric acid employed might vary in strength in consequence of evaporation. It has therefore been proposed to carry out the digestion in closed flasks under what is supposed to be rigorously uniform conditions, and within a shorter time.

While too much importance cannot be attached to uniformity of

methods in soil analysis, there is a limit beyond which it is idle to attempt to go, as regards the strength of acid employed in digestion. For unless we were to vary the amount or strength of the original acid in accordance with the greater or less amount of soluble matter in the soil (ranging all the way from 40 per cent and even more, to 7 per cent only), the strength of the acid *must* vary not inconsiderably during digestion, unless either an indefinitely large quantity of the same were employed, or a preliminary determination were made for each soil before proceeding to the actual preparation of the soil solution. Either expedient is liable to serious objections; it therefore becomes a matter of importance to determine, directly, the extent of the variations to which the acid is liable under the evaporation actually occurring in beaker digestion.

Leaving aside for the moment the question of the proper strength of acid to be employed in preparing the soil solution, it should be remembered that, as Kolb has elaborately shown, chlorhydric acids of constant strength are obtained by free evaporation under the continued influence of any given temperature and pressure.

BEHAVIOR OF CHLORHYDRIC ACID UNDER EVAPORATION.

The fact that chlorhydric acid of nearly constant strength (sp. g. 1.11 per cent, or 23.5 per cent HCl) is readily obtained by the distillation of stronger acid, originally led Dr. D. D. Owen to use such acid in his work on soils; and I continued his practice on the strength of his verbal statement that such acid would on the steam bath remain sensibly (so far as needed in this case) of constant strength.

In view of the objections now made I have thought it best to once more subject the matter to experimental test, the results of which are given in the table below. Fifty ccm. of chlorhydric acid of 1.116 sp. g., obtained by the distillation of the last two thirds of stronger acid under atmospheric pressure, was evaporated on the steam bath to one half its bulk; the same diluted with 10 per cent of water was similarly treated. Furthermore, the same experiment was made with two procelain beakers ("soil pots") covered with watch glasses, being kept on the steam bath for five days, as usually practiced by us in soil digestion. In the latter two cases, the bulk had been reduced to 36 ccm., or by somewhat over one fourth of the original volume.

	Strength of Acid. Per cent Anhydrous HCl.		
	Desk Acid Composition per cent HCl.	Desk Acid Evaporated to ½ its bulk.	Desk Acid Evaporated to 5 cc.
Desk acid in open beaker	22.96	21.49	20.96
Desk acid with 10 per cent water	20.67	21.49	----------
Desk acid in covered porcelain beaker	22.96	21.49	----------
Desk acid with 10 per cent water, in covered porcelain beaker	20.67	21.49	----------

It will thus be seen that under the ordinary conditions of digestion as heretofore practiced in this laboratory, the changes arising from evaporation are absolutely insignificant in comparison with those unavoid-

ably resulting from the variable amount of soluble matters in different soils. There remains, therefore, no rational foundation for the contention that digestion in close flasks offers any advantage over porcelain beaker digestion under watch glass. On the contrary, the chance of increased pressure in a close flask exerting a disturbing influence, together with the greater solubility of the best glass as compared with porcelain, and the greater complexity and liability to accident of the whole arrangement, should tell heavily against its adoption in preference to the other method. Contrary to Kedzie's contention, I am unable to observe any change whatever in the smooth, shining surface of Berlin porcelain beakers that have been in use for fully twelve years.

Kedzie claims as an advantage the shorter time required for digestion in his closed flask. To this I emphatically demur, for the reason that if the action is so much more energetic it is so much the more liable to serious variations of results, in consequence of accidental variations in time of digestion. The plant action which we are trying to imitate is very slow. In Loughridge's experiments, made in 1873, it was found that there was practically no difference in the result obtained, whether the digestion by our method was continued for five or for ten days. If this is generally true (a point now under investigation), it constitutes a distinct advantage, in proving that we have here reached an approximation to a maximum of solvent action, such as will not be easily exceeded by plants within the time in which we are interested. Since that is precisely what we should aim at, I am at a loss to perceive the advantage of the exacerbation of solvent action proposed by Kedzie, Snyder, and others. It should certainly first be shown that there is something to be gained by it, *i. e.*, that the results so obtained are better capable of intelligent interpretation in correspondence with cultural experience.

COMPARISON OF THE ACTION OF HYDROCHLORIC AND OXALIC ACIDS IN SOIL EXTRACTION.

By M. E. Jaffa.

This investigation was undertaken with a view of ascertaining the solvent action of oxalic acid on soils as compared with that of hydrochloric acid. For this purpose two soils were selected, one the *black adobe* from the University grounds, and the other a *reddish, sandy soil* from near Lancaster, Antelope Valley, Los Angeles County, as representing two distinct types.

The hydrochloric acid used was of 1.1150 specific gravity, containing about 23.5 per cent anhydrous acid, and the oxalic acid solution was made of corresponding strength.

The digestion was conducted in porcelain beakers, and continued in the usual way for five days, at the end of which time the analysis was, for the hydrochloric acid solution, made in the prescribed manner. In the case of oxalic treatment, the solution was immediately filtered from the insoluble residue; the filtrate evaporated to dryness in a platinum basin, ignited to expel the excess of oxalic acid, and the resulting residue dissolved in hydrochloric acid and treated as usual.

One phosphoric acid determination answers for both analyses, and,

with the humus and nitrogen contents, is merely inserted to complete the analyses.

Below in tabular form are given the results obtained:

Comparative Analyses of Soils by Hydrochloric and Oxalic Acids.

	No. 1679. Black Adobe Soil, University Grounds.		No. 1607. Reddish, Sandy Soil, Antelope Valley, Los Angeles County.	
	With Hydrochloric Acid.	With Oxalic Acid.	With Hydrochloric Acid.	With Oxalic Acid.
Coarse materials>0.5 mm.	15.00	15.00	30.00	30.00
Fine earth	85.00	85.00	70.00	70.00
Analysis of Fine Earth.				
Insoluble matter	54.50	59.81	80.48	
Soluble silica	19.00 73.50	15.37 75.18	6.77 87.25	89.34
Potash (K_2O)	.73	.73	.49	.47
Soda (Na_2O)	.20	.18	.15	.11
Lime (CaO)	1.15	.62	.97	.41
Magnesia (MgO)	1.08	1.04	.93	.85
Br. ox. of manganese (Mn_3O_4)	.04	.03	.05	.04
Peroxide of iron (Fe_2O_3)	8.43	8.26	4.23	3.86
Alumina (Al_2O_3)	7.92	7.29	4.19	3.42
Phosphoric acid (P_2O_5)	.19	.19	.07	.07
Sulphuric acid (SO_3)	.04	.04	.04	.04
Carbonic acid (CO_2)				
Water and organic matter	6.54	6.54	1.40	1.40
Total	99.82	100.10	99.77	100.01
Humus	1.21		.25	
Humus ash	.94		.20	
Containing phosphoric acid	.04		.01	
Containing silica	.69		.13	
Humus nitrogen in 100 humus	18.58		16.80	
Humus nitrogen in 100 fine earth	.203		.042	
Hygroscopic moisture (absorbed at 15° C.)	11.98		1.22	

An inspection of the data here presented shows that, on the whole, hydrochloric acid exerts a stronger influence in the soil than does oxalic acid; as in both sets of analyses it is noticed that the insoluble residue is, in the case of the hydrochloric acid digestion, about 2 per cent higher than is that resulting from the action of oxalic acid.

The amount of *potash* (0.73 for the adobe and 0.47 for the sandy soil) dissolved is identical in the two treatments, while the quantity of *lime* extracted by hydrochloric acid is about twice that yielded by the oxalic acid, as is indicated by the figures 1.15 and 0.62 for the adobe soil, and 0.97 and 0.41 for the sandy. As regards *magnesia* there is very little difference.

The percentages of *iron* and *alumina* are both lower when oxalic acid is used as the solvent. The water and organic matter percentage is the same, as it was determined only in that portion of the soil used for the phosphoric acid determination.

In summing up, we might say that, except in the case of lime, the results obtained by the action of oxalic acid on soils could receive the same interpretation as that given to those derived from the hydrochloric acid treatment.

It is our intention to digest these two soils with citric acid solution of a strength corresponding to the hydrochloric acid used, and publish the resulting data as soon as possible.

ANALYSIS OF TWO KENTUCKY BLUE GRASS SOILS.

By M. E. JAFFA, for the Association of Official Agricultural Chemists.

The two soils are from near Lexington, Kentucky, and were sent for analysis by Prof. A. M. Peter, of the Kentucky Experiment Station and Reporter on the Methods of Soil Analysis for the Association:

	Soil No. 2.		Soil No. 3.	
Analysis of Fine Earth.				
Insoluble matter	69.02	78.09	73.88	82.24
Soluble silica	9.07		8.36	
Potash (K_2O)		.71		.48
Soda (Na_2O)		.16		.10
Lime (CaO)		.46		.41
Magnesia (MgO)		.41		.32
Br. ox. of manganese (Mn_3O_4)		.05		.04
Peroxide of iron (Fe_2O_3)		5.47		5.04
Alumina (Al_2O_3)		6.58		5.24
Phosphoric acid (P_2O_5)		.71		.40
Sulphuric acid (SO_3)		.04		.06
Carbonic acid (CO_2)				
Water and organic matter		7.23		5.69
Totals		99.91		100.02
Humus		2.43		1.83
Humus ash		2.42		2.17
Containing phosphoric acid		.19		.17
Containing silica		1.22		.98
Hygroscopic moisture (absorbed at 15° C.)		8.62		6.51

The results as shown by the above analyses fully confirm the great productiveness of the Blue Grass region of Kentucky.

The most striking feature of these soils is the very high percentage of phosphoric acid found in them; both the total amount, and that readily soluble portion contained in the humus ash. The figure 0.71, obtained for soil No. 2, was so surprisingly high that a re-determination was rapidly made, giving a result agreeing so closely with the first determination as to leave no doubt of its correctness. No soil that we have examined, so far, shows such a richness in this important element of plant food. The nearest approach in natural soils is in the black waxy prairie soils of Texas (Vol. 6, Tenth U. S. Census), where 0.59 per cent has been obtained; where reported, and in the soils derived from the basaltic formation of central Montana, which have yielded as high as 0.36 per cent phosphoric acid.

The average of this constituent for the humid region of the United States, as derived from the analyses of 466 soils, is .117 per cent, which is less than about one sixth and one third, respectively, the amounts found in soils Nos. 2 and 3. A greater difference is shown when these per cents are compared with 0.083, the average of over two hundred California soils. While the total percentages (0.71 and 0.40) of phos-

phoric acid are so high, those found in the humus ash are also exceedingly large, being 0.19 and 0.17, respectively, which are more than twice the *total* quantity usually contained in the California soils.

These soils being located in a calcareous formation their lime contents are somewhat high, but still are less than one half that found as the average for the California soils, viz., 1.08.

As to potash, while the average of 466 soils of the humid region of the United States is only 0.218, yet such percentages as are here shown are not uncommon in the lowland soils of even the East. No. 2, with its 0.71 per cent, has little more than the average, 0.65, for California, and No. 3 only about four fifths of this amount.

Both these soils are more than adequately supplied with humus, as is indicated by the figures 2.43 and 1.83, respectively.

ON THE NITROGEN CONTENTS OF SOIL HUMUS IN THE ARID AND HUMID REGIONS.

By E. W. Hilgard and M. E. Jaffa.

The "organic" nitrogen of soils has usually been determined by combustion of the organic matter in the whole soil, deducting in some cases that which was known to exist in the nitrate form, from a separate determination.

The combustion method is in any case very inaccurate, so far as it is intended to give the amount of humus nitrogen in the soil. For it necessarily includes the entire organic matter, which varies greatly with the season, and which may or may not ultimately become wholly or partially humified. In order to attain results related definitely to the content of actual functional humus, the latter must be extracted from the soil mass by some solvent which discriminates between the different forms of "organic nitrogen," viz., the humified and the unhumified.

That this cannot be done by direct extraction with fixed caustic alkalies, which inevitably not only dissolve unhumified matters, but also tend to expel ammonia from the amidic compounds, is manifest. Their well-known direct action in humifying the cellulose group of compounds add to the gravity of the objection to their use.

The only method thus far known which distinctly excludes the unhumified matters while eliminating the whole of the properly humified portions, is that of Grandeau: the extraction of the soil first with dilute acid, in order to set the humic substances free from their insoluble combinations with lime and magnesia, and their subsequent extraction with moderately dilute solutions of ammonic or other alkaline hydrates. Notwithstanding the objections raised against this method by Huston and McBride, and its admitted inaccuracy in the case of acid soils, when ammonia is employed for extraction (ammonia from the solvent being then chemically fixed and added to the weight of the humus), its results afford the only clew we have to the true amount of active humus substances in soils. The variations resulting from any moderate variations in the strength of the solvent or in time of digestion, are insignificant in comparison with the utter incommensurableness of the results obtained by any other method.

While we have many desultory determinations of nitrogen in soils

and peats in which the "humus" was determined by lye-extraction or combustion, there are very few of the "*matiére noire*" itself, even Grandeau having failed to come to any definite conclusion regarding its normal nitrogen contents; which, according to his verbal statement to me, has varied, in his own experience, from 3 to 6 per cent and over. In my investigation of soils from the humid region (Mississippi and Louisiana especially) I have usually assumed 4 to 5 per cent as the average.

In view of the extremely small percentages of organic matters, and particularly of the true humus, in the upland soils of the arid region (rarely up to 0.5 and frequently less than 0.2 per cent), I had supposed that a lack of nitrogen might often be the cause of unthriftiness; and in such cases I have repeatedly recommended the use of nitrogenous fertilizers. To my surprise, in several cases such applications proved ineffectual and even injurious, proving plainly that the soil was not nitrogen-hungry. The suggestion that if the small amount of humus suffices in the case of arid soils to satisfy the demand for nitrogen, that humus must be richer in nitrogen than usual, was obvious; and it is the purpose of this paper to communicate, summarily, the results thus far obtained in investigating this problem, by a comparison of the nitrogen content of the *matiére noire* from arid soils, with that from soils of the humid region.

In discussing the question it must be kept in mind that while arid conditions can rarely be fulfilled in the humid region, humid conditions may frequently occur in the arid. The extreme of arid conditions will be found in the uplands and desert plateaus; while in the lowlands, moisture frequently remains within reach of the surface even during the dry season, so that the actual conditions may be semi-arid or locally even humid. Even in the uplands, the bottoms and lower slopes of ravines will be less arid than the higher slopes. Again, it might be expected that close, heavy soils having a high moisture-coefficient may differ measurably in their behavior from the characteristic soils of the arid region (viz., the loose, pervious sandy or "dust" soils), in which eremacausis can progress so freely during the dry season that the surface not uncommonly shows a lower humus percentage than the subsoil. Again, as we ascend a range of mountains the rainfall increases; so that at a certain elevation humid conditions will have replaced the aridity of the valleys or plateaus.

It is therefore not to be expected that all soils from localities west of the 100th meridian should show the characteristics of arid soils; and all degrees of transition between the two extremes are to be looked for. It is also to be expected that when land is irrigated during the dry season, the original characteristics will gradually be modified in conformity with the new régime.

The subjoined table exhibits the results thus far obtained in the investigation of this question. The soils have been arranged in accordance with their known natural occurrence, and include both soils of the extreme arid and humid types, as well as such as within the limits of the arid region must, from their location, be considered as being within the semi-arid or humid region. Thus the soils of plateaus or "mesas" within the arid region must be considered strictly within the arid category; while those of valleys and river bottoms within the same region, being kept in a more moist condition by the greater proximity of bottom water, must be accounted semi-arid only. The soil of marshes, "tule

lands," and swamps is of course within the humid régime, wherever situated. In the hill lands it may easily happen that one and the same soil is strictly under arid conditions on the ridges, while in the ravines and hollows, and in "springy" places, it exists under humid conditions. Hence it is necessary, in conducting such investigations, to work with samples of perfectly known origin.

SOILS FROM ARID REGION.

		Humus Per Cent in Soil	Nitrogen Per Cent in Humus	Nitrogen Per Cent in Soil
	Uplands, California.			
1113	Slate soil (c. l.) Exp. Sta., near Jackson, Amador Co.	.54	16.60	.090
1115	Granite soil (sd.) Exp. Sta., near Jackson, Amador Co.	.85	13.20	.112
1291	Manzanita soil (sd.) McKay Tract, Jackson, Amador Co.	.76	14.34	.109
1117	Granite soil (pine) (sd.) Fleming Tract, Jackson, Amador Co.	.80	15.27	.123
863	Red ridge soil (l.) near Grass Valley, Nevada Co.	2.89	13.91	.402
	Blk. adobe soil (c.) University Grounds, Berkeley, Alameda Co.	1.20	18.58	.203
1147	Loam soil (sd.) front land, Exp. Sta., S. L. Obispo Co.	.66	16.06	.106
1126	Loam soil (sd.) rear land, Exp. Sta., S. L. Obispo Co.	.55	17.27	.095
1423	Chocolate colored soil (l.) Carisa Pl'n., S. L. Obispo Co.	.39	14.36	.056
704	Fresno Plains (sd.) Central Colony, Fresno Co.	.60	18.66	.112
1159	Plains soil (sd.) Exp. Sta., Tulare Co.	.37	16.75	.062
1172	Red lands soil (c. l.) 12 miles east of Tulare, Tulare Co.	.72	14.75	.106
1167	Black lands soil (c. l.) 3 miles west of Tulare, Tulare Co.	1.66	18.19	.302
332	Plateau soil (l.) near Mojave Station, Kern Co.	.28	12.50	.035
1607	Plateau soil (sd.) nr. Lancaster (Mojave Pl'n.), L. Angeles Co.	.25	16.80	.042
1406	Red soil (sd. l.) Arlington Heights, Riverside Co.	.30	15.00	.045
1536	Brownish soil (l.) Windsor Tract, Arlington Heights	.20	18.00	.036
1281	Reddish mesa soil (sd.) Exp. Sta., nr. Chino, Los Angeles Co.	.58	15.50	.090
	Average of uplands	.75	15.87	.101
	Lowlands, California.			
1148	Swale soil (sd.) Exp. Sta. Tract, S. L. Obispo Co.	1.16	9.65	.112
77	Alluvial soil (l.) S.E. cor. Tulare Lake, 1878, Tulare Co.	.47	9.37	.045
585	"Wire grass" soil (l.) near Visalia, Tulare Co.	1.00	14.10	.148
586	Tulare Plains soil (sd.) east of Outside Creek	1.14	10.79	.123
1466	Loam soil (sd.) Miramonte, Kern Co.	.60	10.66	.064
168	Santa Clara River alluvium (st.), Santa Paula, Ventura Co.	.84	7.99	.067
1284	Adobe or moist soil (c.) Exp. Sta, nr. Chino, S. Bernardino Co.	1.99	10.20	.203
506	Colorado River alluvium (st.) near Yuma, San Diego Co.	.75	7.47	.056
	Average of lowlands	.99	10.03	.102

HUMID SOILS FROM ARID AND HUMID REGIONS.

	California.			
207	Eel River alluvium (st.) east of Ferndale, Humboldt County	1.25	6.96	.087
188	Red mountain soil (sd. l.) near Sonoma, Sonoma County	2.54	4.53	.115
110	Putah Valley alluvium (c. l.) Dixon, Solano County	1.71	4.25	.072
213	Marsh soil (sd. l.) Novato Meadows, Marin County	1.54	6.36	.098
37	Redwood valley soil (l.) Pescadero, San Mateo County	2.28	3.07	.070
	Other States.			
	Bog soil, Michigan, No. 26	*33.02	6.08	*2.012
	Back-lands soil (c. l.) near Houma, Louisiana, No. 240	5.07	4.30	.218
	Prairie soil (sd.) Pierce's Junction, Harris County, Texas	2.13	8.66	.184
	Red soil (l.) (old soil) Kohala Plantation, Kauai, H. I.	7.80	2.93	.229
	Average	3.04	5.24	.132

*Introduced only for comparison of the nitrogen percentage in humus; omitted from averages.
NOTE.—c. stands for clay; l. for loam; sd. for sand; st. for silt.

A mere glance at the figures of this table suffices to show the great and rather surprising differences existing between the nitrogen contents in the arid and humid soils. Whatever may be the minor faults or uncertainties of the method employed, the fact that it was applied to all with perfect uniformity, can leave no question as to the general result.

It thus appears that on the average, the humus of the arid soils contains three times as much nitrogen as that of the humid; that in the extreme cases, the difference goes as high as over six to one (see Nos. 37 and 704); and that in the latter cases, the nitrogen percentage in the arid humus actually exceeds that of the albuminoid group, the flesh-forming substances.

It thus becomes intelligible that in the arid region a humus percentage which under humid conditions would justly be considered entirely inadequate for the success of normal crops, may nevertheless suffice even for the more exacting crops. This is most clearly seen on inspection of the figures in the third column, which represent the product resulting from the multiplication of the humus percentage of the soil into the nitrogen percentage of its humus; as appears in comparing the respective averages, or Nos. 1167 and 110 and others.

We must not, then, be misled by the smallness of humus percentages in the arid region, into the assumption of a deficiency in the supply of soil nitrogen.

It is moreover not at all improbable that in the case of a humus substance so extraordinarily rich in nitrogen, the nitrifying process may assume a special impulse, particularly under the concomitant favoring conditions of temperature, porosity, and the invariable presence of earthy carbonates. As is well known, it is precisely in the arid regions that the nitrate deposits that have assumed such capital importance in modern agriculture, have been formed. The same fact is apparent in the numerous analyses of alkali salts in which the presence of notable amounts of nitrates in arid soils is shown. (See reports of the California Experiment Station.) In this connection the soil No. 1159 of the table is of special interest. It is a strongly alkaline soil, containing in its salts a large proportion of carbonate of soda, together with considerable amounts of the nitrate and phosphate of the same base, and potassic sulphate. In leaching this soil a filtrate is obtained of almost inky-black color from dissolved humus. Yet this humus when precipitated is found to contain nearly 17 per cent of nitrogen. It would thus seem that under the conditions existing in this soil the alkali carbonate does *not* prevent the accumulation of nitrogen in the humus substance; yet, at the same time it is often abundantly evident, even to the olfactory sense, that under the influence of a hot sun there is a decided tendency to the disengagement of free or carbonated ammonia. Under such conditions nitrification must be greatly favored, provided the nitric ferment is not prevented from exerting its action by an injurious excess of the alkaline carbonate. In the latter case it is still possible for the plants capable of resisting the corrosive action of the alkali to absorb the nitrogen needed in the form of ammonia directly. But in the view of the known energetic action of gypsum in favoring nitrification, the remarkable effects of plaster on lands afflicted with "black alkali" receive additional explanation.

It is but natural to suppose that the physical and chemical nature of

the soil may materially affect the accumulation of nitrogen in the soil humus, outside of climatic influences. A detailed discussion of the table does not indicate that in general, as might have been expected, the accumulation is greater in porous soils than in compact ones; the reverse seems to hold good. It is also indicated that the presence of a large proportion of earthy carbonates tends to favor the accumulation of nitrogen; which would be in entire accord with the observations of Armsby, Wollny, and others, regarding the favoring of oxidation (formation of CO_2) by lime or its carbonate when in contact with organic substances. On the other hand, the presence of a large proportion of finely divided ferric hydrate seems to tend in the opposite direction, contrary to what, according to our knowledge of that substance under apparently similar conditions, would have been expected. I have repeatedly noted, both in the arid and humid regions, that the common impression that strongly ferruginous soils are usually poor in humus, is a delusion due to the obscuration of the dark humus tint by the rust color of the ferric hydrate.

There is one general point that is pregnantly illustrated by this investigation, viz., the marked difference in the mode and results of the decomposition of animal matter on the one hand, and of vegetable on the other. In the former case we have, first of all, a copious evolution of ammonia compounds and their analogues; and under natural conditions at least the residues of the process, if any, are mostly poor in nitrogen. In the case of vegetable matter, under similar conditions, the carb-hydrate portion of the mass is first attacked, and the residue becomes richer in nitrogen, until finally it accumulates to the extent of a higher percentage than in the albuminoids themselves. It is not altogether easy to formulate a general explanation of these facts; but they are certainly of great practical as well as theoretical interest.

INVESTIGATIONS IN SOIL PHYSICS.

By R. H. Loughridge.

[In view of the many significant facts brought out in the course of soil investigation during twenty-four years past, it is thought best to put on record in the following pages a summary presentation of observations thus far made by us, in order that future experimenters may have the benefit of the same. The complexity of the subject is so great that perfectly definite conclusions cannot be reached without the concurrent investigation of a vast number of natural soils under varied conditions, from varied materials, and the concurrent discussion of the results from both the chemical and physical point of view.—E. W. H.]

THE MECHANICAL COMPOSITION OF SOILS WITH REFERENCE TO MOISTURE AND WATER MOVEMENTS.

The analysis of soils with reference to their mechanical constituents has been in progress at this Station at intervals for fifteen years, and the results are here combined in one table, in order to draw as far as possible some conclusions, either positive or negative, as to the relation of the various sediments or ingredients to the power possessed by soils to absorb hygroscopic moisture, to their capacity for holding water, and to their power of transmitting water by capillarity.

These analyses have all been made by means of the soil elutriator

Number of Soil.....
51
863
67
68
1113
1115
1645
10
110
8
9
233
6
1055
1159
1678
1167
588
77
676
1647
188
1655
643
1
2
1679
4
788
986
1586
168
1147
1148
130
1281
1284
1663
47
506
1197

are, of course, out of the question.

In attempting to correlate, quantitatively, the soils' alumina obtained by the ordinary HCl treatment, with the silica soluble in sodic carbonate after the operation, it fre-

* Landw. Versuchstationen, 35, 1888, p. 69 *et seq.*

† Proceedings of the Am. Ass'n for the Advancement of Science, Portland meeting, 1873, page 83.

possible some conclusions, either positive or negative, ... of the various sediments or ingredients to the power possessed by soils to absorb hygroscopic moisture, to their capacity for holding water, and to their power of transmitting water by capillarity.

These analyses have all been made by means of the soil elutriator

designed by Professor Hilgard many years ago (described in the report for 1892), and most of them under his direct supervision. Many of them have already been published singly in the former reports of this Station, while others have been made during the past two years, and appear here for the first time.

The "clay," so called, is obtained by allowing the magma of soil and water diluted to a column 200 millimeters in height, to remain for twenty-four hours, all of the coarse material settling to the bottom and the clay remaining in suspension. The latter is then decanted, the operation repeated upon the sediment until the liquid remains clear after that time, and finally the clay thrown down from suspension by a solution of salt. As thus obtained by twenty-four hours' suspension, the clay is really a mixture of very fine material whose grains are partly, perhaps, immeasurable, but of varying diameters. This is made apparent by allowing the clay water to stand more than twenty-four hours, when sediments are found at the bottom of the beaker; and even in the column itself is seen stratification of material in clouds of varying densities, showing differences in weight or size of particles. True colloidal clay remains in suspension in pure water for an indefinite period; we therefore have in the "clays" of the analysis an indefinite amount of true colloidal clay on the one hand, with its high absorptive power, and on the other a quantity of extremely small and perhaps partly immeasurable solid grains of sediment, whose surface area alone marks their power for absorbing moisture.

The following definition of clay is extracted from an article on "The Determination of Clay in Soils" from the pen of Professor Hilgard, and published in Agricultural Science, Vol. VI, page 156:

> The "clay" that is of such high importance as a physical soil ingredient is not the aggregate amount of kaolinite in all its forms, but only that colloidal portion which contributes to the plasticity and absorbent power. There is no reason to include in this designation the chalky kaolinite particles that in almost all respects act only as do other mechanical constituents, of whatever chemical composition, and are no more plastic than so much talc or fine silex. It was the preception of this fact * * * that led me to postulate as a proper period for the subsidence of non-plastic materials, the space of twenty-four hours. Even then a certain proportion of the finest particles of quartz and other minerals remain with the true clay; and there also remains, in all earths colored with *ferric hydrate*, a considerable proportion of that substance, sometimes to such an extent as to diminish materially the plasticity and other characteristics of true colloidal clay. Since according to the interesting researches of Van Bemmelen,* the colloidal ferric hydrate performs, with the "hydrogels" of silica, alumina, and humus substances, and probably some zeolitic compounds, functions similar to that of clay in all respects except that of plasticity, the presence of these colloids in the finest "clay" is to be expected and must be taken into account in forming an estimate of the soils' physical properties. The ratio of silica to alumina in pure kaolinite is nearly 46:40; and in numerous cases we find this proportion very nearly realized in analyses made with hot HCl, and subsequent boiling with Na_2CO_3; more commonly, however, the soluble silica in the residue from HCl treatment is in excess; at times very considerably so; pointing (particularly when combined with the fact that in the raw soil the soluble silica is insignificant in amount) to the existence of a large proportion of easily decomposable silicates—doubtless zeolites. In Loughridge's investigation on the composition of the sediments obtained in the mechanical analysis of a very generalized soil of northwest Mississippi,† the soluble silica in the colloidal "clay" was found (by HCl treatment) to be 33.1 per cent against 18.2 of alumina, 16 per cent of insoluble silt remaining; showing a large excess of silica over the amount required for kaolinite, the calculated percentage of the latter in the colloidal "clay" being 46.04 per cent. The next finest sediment, lying between the clay and 0.25 mm. h. v., gives only 11 per cent of kaolinite (calculated); that of 0.25 mm., 6.7 per cent; that of 0.5 mm., 2.56 per cent. But the latter sediment is completely non-plastic and evidently should not be included, while the coarser sediments are, of course, out of the question.
>
> In attempting to correlate, quantitatively, the soils' alumina obtained by the ordinary HCl treatment, with the silica soluble in sodic carbonate after the operation, it fre-

* Landw. Versuchstationen, 35, 1888, p. 69 *et seq.*

† Proceedings of the Am. Ass'n for the Advancement of Science, Portland meeting, 1873, page 83.

quently happens that a very large proportion of the alumina found has neither silica nor any other acidic oxide to combine with. It is manifestly present, in part, in one or several other forms, among which in some cases the hydrate (*e. g.* gibbsite) seems to be the only imaginable one. I have formerly found a number of such cases in the soils of Mississippi; they are even more common in a certain class of California soils, notably in those from the great valley and the lower foothills.

It may be claimed that even the pulverulent kaolinite particles excluded from the clay determination made by the twenty-four hours' subsidence, will, in the soil, in the course of time, become macerated and ground into colloidal clay. Probably *all* the conditions contributing to the conversion of pulverulent kaolinite into plastic clay are not yet understood. Johnson has shown that protracted trituration will render floury kaolin sensibly plastic, and the effect of the boiling and kneading ("tempering") of natural clays is well understood in practice. In the latter cases, however, the effect is doubtless largely due to the dissolution of preëxisting flocculent aggregates, rather than to the further reduction of crystalloid kaolinite to the colloidal condition. The very slight trituration that can occur even in the best cultivated lands by the ordinary work of tillage can produce no sensible effect in the latter direction. It has never been claimed that cultivation increases the closeness or plasticity of soils; and hence for the present and practically permanent nature of any soil the *actual* contents of colloidal clay must be considered the measure, to be ascertained by analysis.

It must be remembered, then, that in the following discussion the term "clay" represents the sediment remaining in suspension after twenty-four hours' subsidence, and comprises the extremely fine kaolinite particles, the silicic hydrate, the acid-soluble hydrated silicates or zeolites, the ferric hydrate, aluminic hydrate, and humic hydrates; each of these has doubtless an attraction for water or moisture peculiar to itself, and its presence in the clay, in greater or less proportion, modifies the hygroscopic, water-holding, and capillary powers of the latter, and therefore of the soil. That the "clay" contains nearly all of the zeolites and other mineral salts soluble in hydrochloric acid, was indicated by a series of analyses of the several soil ingredients, obtained from a Mississippi soil, already mentioned in the above paper by Professor Hilgard as having been made by us. It is therefore not only an important physical constituent of all soils, but the chief repository for plant food.

Sources of Water Supply for Plants.—During seasons of drought plants are dependent upon three natural sources of moisture supply in the soil, for preservation of vitality and for growth, viz.: hygroscopic moisture in the surface soil absorbed from the atmosphere; a greater amount of moisture accumulated from rains and held in the soil; and the still greater accumulation of ground-water at depths of many feet from the surface; and by condensation of aqueous vapor in consequence of temperature changes. This latter cause is for the present discussion left out of consideration.

The supply from the ground-water is transmitted to the plant roots by capillary movement between the soil particles, and if the conditions are favorable for such easy movement, and the source not too far below the limit of capillarity, it is entirely sufficient for the growth of the plant. Thus far our experiments show that the best of our soils have the power of raising moisture by capillary movement to a height of less than five feet, while in sandy soils the limit is far less. Should the roots of trees or plants fail to penetrate to within reach of this supply, then they must rely upon the amount of water that the soil is capable of holding from the winter rains (or from condensation by change of temperature). This amount is dependent upon the mechanical and chemical composition of the soil, and is the chief source of supply, especially for deep-rooted crops. When, however, the roots of shallow-rooted crops

fail to reach this storage supply, they are dependent either upon artificial irrigation or that moisture absorbed from the atmosphere known as *hygroscopic moisture*. The amount of the latter is very meager, but in good soils of fair tilth, there is enough to sustain vitality and in many cases to promote growth.

In the following discussion of these sources of water-supply it is proposed not to take our entire series of chemical analyses of soils, comprising several hundred moisture determinations, but only those in which both the chemical and mechanical constituents have been ascertained; and thus if possible to reach some conclusion as to the influence of these several constituents upon the absorptive power of soils.

INFLUENCE OF SOIL COMPOSITION UPON HYGROSCOPIC MOISTURE.

It is a well-known fact that all solid particles condense upon their surfaces a thin film of moisture from the atmosphere, and that the thickness of this film is dependent upon the degree of moisture in the atmosphere and upon the temperature; that the drier the air the less will be the amount of moisture upon solids. It goes without saying, therefore, that the greater the surface thus exposed to the air within a given volume the greater will be the percentage of moisture in an accumulation of small solid particles such as we find in soils.

There is, however, another factor, and a very strong one, that influences the absorption of moisture by soils, and that is the chemico-physical character of the particles and constituents. Among these may be specially mentioned the humus compounds and the hydrated silicates or zeolites, as well as ferric hydrate, and to a certain extent aluminic hydrate and colloidal clay. All but the latter may be regarded as the soluble constituents of a soil; not soluble in water, but in weak acids, and representing the portion available for the use of plants.

Absorptive Power of the Several Mechanical Soil Ingredients.—A few experiments have been made with the finer of the sediments (obtained in the mechanical analysis) to ascertain their power of absorbing moisture from a saturated atmosphere, and at a constant temperature of about 15° C. Except in the matter of securing large amounts of each, there was no trouble with the sediments, and they were used as obtained from the elutriator. But for the clay, a portion had to be specially prepared by evaporating the clay water and its suspended clay to dryness; for as ordinarily treated for weighing, it is thrown down from suspension by a solution of salt, which is then eliminated by the use of chloride of ammonium. The presence of the latter has its effect on the absorptive power of the clay, as was shown by the experiments.

The following are the results obtained from a sample of the black lands soil near Tulare (No. 1167), the red soil from Grass Valley, Nevada County (No. 863), and the black adobe soil from the University grounds, Berkeley (No. 1679), and the sandy soil of Castroville (No. 1595):

Hygroscopic Moisture Absorbed by Clays and Silts.

No.	Soils.	Entire Soil.	Clay.	Silts.			
				<0.25.	0.25.	0.5.	1.0.
1167	Black lands soil, Tulare	5.34	17.60	7.96	2.91	1.73	----
1167	Black lands soil, with salt	5.34	15.56	----	----	----	----
863	Red soil, Grass Valley, with salt	14.20	13.24	12.06	----	----	----
1679	Black adobe, Berkeley	11.98	22.25	6.05	----	----	----
1595	Sandy soil, Castroville	1.15	----	----	----	----	0.31

The amount of moisture absorbed by the several clays in the above table differs very greatly; it is highest in the black adobe and least in the red ferruginous soil of Grass Valley. In any case the amount is greater than in the silts.

It has already been remarked that the clays may be regarded as of complex character, combining not only grains of extremely fine division, but also colloid material, such as ferric, aluminic, silicic, and humic hydrates, and that these exist in the soils in greatly varying proportions. Thus in the black adobe with the highest moisture percentage there is 40 per cent of these hydrates; in the black lands of Tulare 21 per cent, and in the Grass Valley red clay there is as much as 62 per cent. In the first two, however, there is more of the silicic and aluminic hydrates than in the latter, and these have a stronger attraction for moisture than the ferric hydrate which forms the greater part of the clay from Grass Valley. It thus seems more than probable that the large percentage of moisture absorbed by the adobe clay is substantially due to the excess of the true colloidal clay above that contained in either of the other soils.

The negative effect of some salts, such as ammonic chloride, is shown in the above table; the Grass Valley soil, entire, has a moisture coefficient of 14.2, almost the maximum of the list of forty-two soils, yet lower than its clay alone in which ammonic chloride was present. The black lands soil with the salt absorbed 15.5 per cent, but with most of the chloride driven off it absorbed 17.6 per cent. The amount absorbed by the entire soil was only 5.38 per cent.

The presence of this ammonic chloride salt in most of the above clays prevents at present a discussion with regard to the chemical nature of the soluble compounds held by each. In the general discussion of the soils themselves with reference to hygroscopic moisture and water-capacity they will again be mentioned.

The materials coarser than clay in the above list have in all cases a lower moisture coefficient: the finest silts varying in amount because of the presence of some soluble silicates. The coarser the grains comprising the group the smaller is the percentage of moisture, until in the sands alone we find less than 1 per cent.

The following table, comprising those soils of which both mechanical and chemical analyses have been made, is arranged in the order of high to low percentages of hygroscopic moisture for each division of soils into clays, clay loams, loams, sandy loams, and sandy soils. The other columns show the percentages of clay, and of clay combined with the several series of silts and fine sands, which gives to each column an additional amount of coarser material to that presented in the preceding

column. We can thus compare the relative percentages of moisture with the amount of various sediments in each soil, and also, in a measure, the effect produced by the combinations. In the last columns showing chemical composition, the soluble silicates, embracing all the matters soluble in hydrochloric acid, except lime carbonate and iron oxide, occupy one column, while the total of soluble matter fills the third column.

A glance over the several columns shows that there is no uniform or nearly uniform gradation in the percentages of material running parallel with the moisture figures from highest to lowest; that the soil having the highest moisture is not characterized by the highest clay or the highest combination of clay and silts which comprise the finest ingredients, and are supposed to offer the greatest surface to the deposit of moisture.

We may say, though, that as a very general rule those soils having the largest amount of finest ingredients belong to the class of highest moisture coefficients, and that *vice versa* the coarse sandy soils are very low in moisture; but it is not an exact rule, for even in those soils embraced in the table there are many striking exceptions, and for which the cause must be sought, not in mechanical composition alone but in the chemical, and even then other causes seem in some cases to have a controlling influence.

The general question at present is, what is it in the soil that causes the greater absorption of moisture, the clays singly or when combined with the fine silts, with their large surface area; or is the amount of suluble chemical compounds of greater influence than these?

Perhaps the most feasible method of making comparisons between the several ingredients as a whole, is that of ascertaining the number of points or movements the figures in each column would make if rearranged in the order of highest to lowest, each figure being moved upward. A comparison of the several totals would show at a glance the column most in accord with the column of moisture percentages. As a matter of course, the fewer there are of such movements the more nearly will such a column be in accord with that of the hygroscopic moisture, and will indicate a stronger influence upon the absorption of such moisture.

A number of the soils have not been analyzed chemically, and, for purposes of comparison, we will omit them from the list; we thus find the following as the number of points through which the figures in each column will have to be moved for adjustment from highest to lowest:

Mechanical Ingredients.

Clay alone	147 points.
Clay combined with the two lowest silts	148 points.
Clay with silts to .5 mm. hydraulic value, inclusive	156 points.
Clay with silts to 1 mm. hydraulic value, inclusive	160 points.
Clay with silts to 2 mm. hydraulic value, inclusive	165 points.

Chemical Ingredients.

Total soluble compounds	136 points.
Soluble silicates alone	120 points.

The result strongly indicates that the soluble silicates or zeolitic compounds have a stronger influence upon moisture absorption than the mere surface area of the particles alone. These silicates doubtless represent largely the colloidal portion of the "clays," and their low percentage in soils with high clays doubtless affords the reason why in the table some of the latter stand below soils with lower clay percentages.

MECHANICAL ANALYSES OF SOILS ARRANGED IN THE ORDER OF HYGROSCOPIC MOISTURE.

No.	Name and Character.	Locality.	Hygroscopic Moisture.	Mechanical Analysis.					Chemical Analysis.			
				Clay.	Clay to .25 mm.	Clay to .5 mm.	Clay to 1 mm.	Clay to 2 mm.	Soluble Silicates.	Total Soluble Material.	Ferric Hydrate.	Humus.
	CLAY SOILS.											
6	Black adobe	Stockton	14.53	32.63	74.0	79.5	85.1	87.1	22.3	29.1	7.7	
863	Red soil	Grass Valley	14.20	24.78	57.1	59.5	65.3	71.0	54.0	62.3	9.5	2.9
188	Red mountain soil	Sonoma	13.70	52.24	67.9	71.8	77.9	82.4	26.9	52.9	29.7	2.5
643	Black waxy soil	Colton Ranch	13.51	43.54	79.1	81.7	84.8	87.5	28.4	39.5	12.7	1.5
1679	Adobe soil	University	11.98	44.27	69.6	73.2	77.7	83.1				
68	Adobe	Chinese Camp	11.19	26.10	62.5	65.5	70.3	76.3	34.2	43.2		1.6
676	Red volcanic soil	Clear Lake	11.11	29.84	61.2	64.9	71.0	77.0	34.3	44.8	12.0	1.4
77	Dry bog soil	Tulare Lake	10.38	29.79	45.2	47.4	55.6	64.2	18.0	34.0	5.8	.5
110	Alluvial soil	Putah Creek	10.32	31.49	76.8	80.4	85.4	89.8	20.7	28.7	9.1	1.7
789	Upland adobe soil	Mission San José	9.74	34.16	54.0	56.6	58.1	61.7	15.0	18.8	4.4	.7
506	Bottom soil	Colorado River	9.26	23.97	55.8	67.1	79.7	88.1	16.4	37.0	4.7	.8
8	Non-alkali soil	Stockton	9.18	20.80	56.1	62.7	68.3	75.6				
1	Black adobe soil	University	7.52	31.93	57.7	61.1	65.9	73.4	16.7	21.4	5.4	
2	Black adobe subsoil	University	5.14	33.53	61.7	67.6	74.6	81.0	24.1	31.3	8.3	
986	Sandy adobe soil	Cupertino	5.10	20.54	48.2	52.1	55.6	59.9	13.2	19.9	7.7	1.0
1655	Red vineyard soil	Crabbs, Oakville	4.20	21.73	58.5	63.0	68.5	75.7	19.1	26.8	8.8	1.1
9	Alkali soil	Stockton	2.63	26.10	54.0	63.5	69.7	75.9				
	CLAY LOAMS.											
67	Mining slum soil	Chinese Camp	10.26	18.47	46.7	54.9	65.5	77.5	18.1	27.4	10.5	0.4
1113	Red foothill soil	Experiment Station	6.00	16.43	51.3	61.3	69.0	77.2	23.8	35.3	13.7	.5
168	Valley silt soil	Santa Paula	5.49	15.02	30.2	35.3	43.3	56.0	8.6	11.9	3.9	.8
1645	Alluvial soil	Yuba City	5.27	15.30	58.8	68.9	77.1	85.4	23.7	32.4	10.0	1.3
4	Adobe ridge soil	University	5.18	18.92	41.0	47.8	57.2	63.8	11.0	15.0	4.6	
1647	Redwood soil	Guerneville	5.14	16.54	37.0	40.4	44.5	51.7	18.4	24.2	6.8	.6
1663	Red mesa soil	Riverside	5.06	19.37	37.2	41.4	53.6	72.1				
	LOAMS.											
10	Sediment soil	Sacramento	9.18	12.06	55.6	68.7	82.4	92.7	25.1	31.4	7.3	
1678	Sandy alkali soil	Tulare	6.41	10.42	45.3	48.1	54.6	62.3				
1115	Granitic soil	Amador	5.93	11.86	32.8	36.1	40.0	45.9	21.0	26.3	6.2	.5
1284	Moist-land soil	So. Cal. Exp. Station	5.81	13.44	35.5	40.4	46.4	59.9	13.6	28.8	7.3	2.0

1167	Black lands soil	Tulare	5.38	14.65	38.9	44.4	47.9	54.9	16.2	21.2	5.8	1.3
586	Plains soil	Outside Creek	4.86	10.48	34.9	37.1	47.7	53.9	16.5	22.2	6.6	1.1
1055	Red sandy loam	Fresno	3.62	11.01	29.9	36.4	44.9	57.6	13.4	20.9	8.5	.4
51	Red foothill soil	Auburn	3.17	13.91	45.8	51.4	62.8	78.8	18.2	31.6	13.4	1.1
130	Reddish loam	San Gabriel	2.30	10.70	27.3	33.9	39.0	46.1	13.1	19.4	7.3	.....
	SANDY LOAMS.											
1159	Sandy plains soil	Tulare	4.00	5.71	16.7	20.8	26.3	33.4	13.7	20.6	7.6	.4
47	Red mesa soil	National Ranch	2.30	9.66	21.0	24.2	28.0	33.9	9.6	13.3	4.4	.6
1281	Mesa soil	Chino Ranch	1.98	7.60	26.1	31.6	35.5	41.9	13.4	22.5	8.2	.6
1147	Sandy loam soil	Paso Robles	1.84	7.40	25.2	31.2	39.8	48.2	5.8	9.6	4.3	.7
	SANDY SOILS.											
1197	Gila bottom soil	Gila River	3.48	3.21	8.7	10.7	13.9	24.1	8.9	23.1	7.4	.....
1148	Swale soil	Paso Robles	3.43	3.09	24.6	27.8	38.1	45.9	6.7	10.0	3.8	1.2
1595	Sandy soil	Castroville	1.15	2.60	8.9	9.2	12.7	13.6	.....	.....	.....	.....
233	Sandy soil	Morano	.79	2.82	5.2	6.0	6.5	8.7	.....	.....	.....	.....

THE EFFECT OF THE DIFFERENT INGREDIENTS UPON MOISTURE ABSORPTION.

"*Clay.*"—A glance at the column of "clay" percentages in the soils shows immediately that there is no very close correspondence or ratio between the clay and amount of moisture absorbed by the soil. The combined surface area of the particles of clay in a clayey soil is very great, and in the loose condition in which they were exposed to an atmosphere saturated with moisture at a temperature of 15° C. we would naturally anticipate a correspondingly large condensation of moisture, and that the highest percentage of clay would bring with it the highest percentage of moisture for that soil; but such proves not to be the case, for the red mountain soil with its 52 per cent of ferruginous clay absorbed but 13.7 per cent of moisture, while the black adobe with but 32.6 of clay absorbed 14.5 per cent; and an adobe ridge soil with 33.5 of clay could be made to take but 5.1 of moisture. Again, we find that an alkali soil with 26.1 of clay stands near the foot of the column of moisture percentages with only 2.6 per cent. And thus all down the column, we constantly find high "clays" with comparatively low moistures and just above each a low clay with higher moisture.

In the following table are arranged sixteen of the soils with highest clays in their natural order, in order to show more clearly this variation, and the rank of each with reference to moisture:

No.	Soil.	Clay Percentage.	Moisture Percentage.
188	Red mountain soil	52.24	13.70
1679	Adobe soil	44.27	11.98
643	Black waxy soil	43.54	13.51
789	Upland adobe	34.16	9.74
2	Black adobe soil	33.53	5.14
6	Black adobe soil	32.63	14.53
1	Black adobe soil	31.93	7.52
110	Alluvial soil	31.49	10.32
676	Red volcanic soil	29.84	11.11
77	Dry bog soil	29.79	10.38
68	Adobe soil	26.10	11.19
9	Alkali soil	26.10	2.63
863	Red soil	24.78	14.20
506	Bottom soil	23.97	9.26
1655	Red vineyard soil	21.73	4.20
986	Sandy adobe soil	20.54	5.10

The high percentage of "clay" of the red mountain soil is due largely to the iron oxide that it contains (26 per cent for the whole soil, a part of which, however, passed over into the next silt class), so that it should properly give its place to the adobes which naturally have very large clay percentages, and all with two or three exceptions stand at the head of the moisture list.

Among the silt analyses of Mississippi soils and subsoils, given in the paper of Professor Hilgard, read before the American Association for the Advancement of Science, in 1873, we find an analysis of a white pipe-clay; its composition is:

Clay	74.65
Finest silt	21.15
Fine silt	2.00
Coarser material	0.36

The clay in this may be regarded for the most part as kaolinite, or true clay, without the presence of much of the zeolitic mineral which

forms an important constituent of the clay of soils. Its moisture coefficient was found to be 9.09, or a little more than one half of that of the soil clays reported on a previous page.

In the same table we find that the Flatwoods soil of Pontotoc County with only 25 per cent of clay has almost the same moisture coefficient (9.33), and that a red hills soil of Attala County absorbs 18 per cent of moisture, or twice that of the pure clay. This red hill soil has about 25 per cent of ferric hydrate, and to this may be credited the high absorptive power.

Again, in the marsh soils of West Pascagoula, Mississippi, as reported in the Geology of that State, we find a predominance of coarse material and very little clay, but a large percentage of organic matter. The clay thus plays but an insignificant part, yet we find the moisture percentage to be 15.00, clearly due to the organic matter.

The conclusion is apparent that the "clays" do not in themselves control the amount of hygroscopic moisture that is absorbed by soils, although they do largely influence it.

If we were to rearrange the present column of clay percentages of the forty-one soils presented in the table, by moving them up until they read from highest to lowest, there would be a total of 211 movements.

Clay and Silts.—If we add to the clays the two lowest of the silt groups in the elutriator series, we find that the black waxy soil of Contra Costa County (No. 643) is highest, and the alluvial soil No. 110 second, in combined weight; the black adobe No. 6 which has the highest moisture coefficient is brought to the third place instead of the sixth, when its clay alone is considered, thus indicating that so far as itself is concerned, the combined fine material is more hygroscopic than its clay.

If to this combination of clay and silt we add the percentages of other silts, the parallelism between each column and that of the hygroscopic moisture is not improved, but on the contrary the irregularity becomes greater, thus showing that the three finest of the ingredients has the greater absorptive power. In the rearrangement of the figures in each column, as in the case of the clay, we find a gradual increase in the number of points passed for each column, and from 211 and 198 in the two first columns of clay, and "clay and finest silts," respectively, we have at the last 221 for the clay and total percentages of silts.

In this connection it may be well to briefly refer to a remarkable group of soils from the Sandwich Islands, specimens of which have been recently received and are being examined. They are very highly ferruginous and very rich in mineral matter soluble in hydrochloric acid, more than 50 per cent being thus soluble. The moisture coefficient is extremely high in all of the soils examined, ranging from 16.0 to 37.4 per cent; and in each may be attributed to some special ingredient. Thus, the soil with 37 of moisture has the highest humus, 10.9, with high percentages of hydrated silicates and ferric hydrate. The soil with 29 per cent of moisture has very little of hydrated silicates, but a very large amount of the hydrate of alumina; its humus is 7.2. Another soil, with 21.7 of moisture, has very little humus, but about 18 per cent of free hydrated silica. Mechanical analyses have not been made of these soils, but as far as we can judge from their character, they have practically the same amount of clay and fine material, and if their moisture coefficient were dependent alone upon this, there should be little difference in their percentages.

CHEMICAL COMPOSITION WITH REFERENCE TO MOISTURE ABSORPTION.

We are not prepared now to undertake to consider the relation of each of the chemical compounds within the soil to the hygroscopic coefficient, for the state of combination of these elements is a matter of some uncertainty; we can only take as a whole the total of substances soluble in hydrochloric acid and the isolated group of soluble silicates (including the hydrated silicates of alumina, potash, soda, lime, etc., hydrated silica, and aluminic hydrates). The ferric hydrate and lime carbonate are included in the soluble material. There are only three in the list of soils given in the table that contain a very large amount of aluminic hydrate, viz.: the red soil No. 863 from Grass Valley, with 25 per cent; the red volcanic soil of Lake County, with 17 per cent, and the alluvial soil of Putah Creek, Yolo County, with its 9.2 per cent.

In glancing over the columns of total soluble substances and of soluble silicates as arranged in the table, there is seen to be the same irregularity as noted in that of the mechanical ingredients, though not to so great an extent. There is also this notable difference, that, with the exception of the black adobe (which has the highest moisture percentage and only 29 per cent of soluble matter), the five soils having highest total soluble matter, and also highest soluble silicates, stand highest in hygroscopic moisture. This cannot be said of the "clays." It is notable also that in the rearrangement of the figures to read from highest to lowest the number of points to be passed is less than in rearrangement of the columns of mechanical ingredients.

These results appear to clearly indicate that the influence of the chemical constituents of a soil toward moisture absorption is greater than of a mere mechanical subdivision as represented by "clays" and silts.

From the above it will be seen that there is required a great deal more of direct investigation of soils *in their natural condition* to elucidate this important subject. Artificial mixtures in which kaolin is made to represent the "clay" (as has been done by some European investigators), cannot give results applicable to natural soils.

CAPACITY OF SOILS FOR HOLDING WATER.

The power of a soil to hold within itself a supply of liquid water derived either from rains, interior condensation of moisture, or from underground sources, is of great importance; for upon this supply is dependent the moisture and the solution of necessary nutritive mineral matters to promote the vitality and growth of the plants. The conditions most favorable for such storage of moisture (though not for the growth of plants) are not alone the combined surface area of the soil particles as in the absorption of hygroscopic moisture of the air, but in the amount of space between the particles in bulk; provided the adjacent particles are not so far apart as to prevent the entire space being filled with the water by natural capillary attraction. In coarse, sandy soils, for instance, the interspaces are so great that percolation and drainage rapidly take place, a portion of each space is left vacant, and the soil is found to be low in water-capacity. On the other hand, in clayey soils the interspaces are

so extremely minute as to be entirely filled with water. In loams which combine both clay, silt, and sand, the two former fill, to some extent, the spaces between the grains of sand, and thus increase the retentive power.

It must always be remembered, however, that the chemico-physical character of the soil particles, and other conditions surrounding them, have a great deal to do with their relations to water; in some instances fine soils ("dust soils") have been found which in a dry condition refuse to take water (each drop of which rolls up into a little ball, the surface of which is covered with a thin film of the soil), and which, even after long contact, fail to permit free absorption or percolation.

A prominent case in point is thus mentioned by Professor Hilgard as observed by him in the State of Washington a few years ago:

"The difficulty of making soils take irrigation water is a matter of common note and complaint in the alluvial plains bordering the Yakima River, particularly in the northern division known as the Atahnam prairie. When first taken into cultivation the soil is so difficult to penetrate with moisture that to reach 12 inches sidewise from the ditch sometimes requires as many hours. In the upper part of the plain mentioned, along the Nachees, small irrigating ditches have to be run three feet apart, at most, in order to obtain a uniform stand of grain; when farther apart the grain in the middles would dry up as though unirrigated.

"The same has been noted at other points in this State and Oregon and Washington, where such 'dust soils' prevail. These soils have the following mechanical composition:

Dust Soils of Washington and Oregon.

Mechanical Composition.	17 Atahnam Prairie, Yakima Co., Wash.	37 Rattlesnake Creek, Kittitas Co., Wash.	79 Plateau on Willow Creek, Morrow Co, Oregon.
Colloid clay	.93	3.59	1.27
Silt (of <.25 millimeters hydr. value)	30.93	13.06	32.29
Silt (of .25 to .5 millimeters)	3.20	5.82	12.75
Silt (of .5 to 2.0 millimeters)	7.18	27.37	37.51
Sand (of 2.0 to 8.0 millimeters)	21.88	43.78	10.92
Sand (of 8.0 to 64.0 millimeters)	32.39	4.57	3.97
Total	96.57	98.18	98.72

"Clay is shown to be present in very small amounts only; there is a good deal of the finest silt (<0.25 mm.), and then there occurs a conspicuous break in the small amount of sediment just above that point."

The water-capacity has been determined for nearly all of the soils of the State that have been chemically analyzed, but for the present purpose of studying this property with respect to both the physical and chemical nature of the soil, only such are taken for discussion as have had the proportion of mechanical ingredients determined.

These are comprised in the following table, and are arranged according to general character of *clay soils* having 20 per cent and above of clay, *clay loams* with 15 to 20 per cent of clay, loams with 10 to 15 of clay, *sandy loams* with 5 to 10 of clay, and *sandy soils* with less than 5 of

clay, the soils of each division arranged according to the respective water capacities. The other columns show respectively the percentages of "clay," and of clay combined with other ingredients of increasing hydraulic value, as determined in the analysis.

In these determinations uniformity is preserved with the methods of mechanical and chemical analysis by using only the material that has a diameter of less than half a millimeter.

Method Used.—The method of capacity determination used was that suggested by Professor Hilgard in Bulletin 38, Division of Chemistry, U. S. Department of Agriculture. A circular brass box with perforated bottom, containing exactly 25 cc. and holding a column of soil 10 mm. height, is filled with the air-dried soil, which is settled by a gentle tapping of the box on the table. The surface is then struck off level by a thread of silk and the box and soil weighed. It is best to rest the box upon a glass plate, both when weighing dry and when wet, to protect the scale pans.

Place the weighed box and soil on a triangle submerged just beneath the surface of the water in a somewhat wide vessel; allow it to stand until fully saturated (not less than one hour in order to insure the complete wetting of compacted soil particles); then wipe rapidly with filter paper or an absorbent towel and weigh again without unnecessary delay. Calculate from the weighings the results with respect to both weight and volume.

Comparison of Soils by Volume and by Weight.—A glance over the column (the last but one in the table) giving the weights of equal volumes of the various soils shows great differences even in soils of the same class, a difference due to the character of the ingredients. Thus among the clay soils we have weights varying from 78 to 111 grams, with an average of 102 grams per 100 cubic centimeters. Among the clay loams, from 98 to 111, with an average of 108 grams. The loams are still more varied, and reach from 76 to 120, with an average of 100.7. The three sandy loams have an average of 121; while the sandy soils average 129 grams. The coarse sandy soil from Morano, one of the last group, is really representative of another class, for its ingredients are coarser, and its weight is far above any of the others, 157 grams, or 5.5 ounces per 100 cc.

As a general rule the sandy soils are the heaviest, and the loams or soils containing the greatest percentages of light, silty material are the lightest. The soils more clayey in character are somewhat heavier than the loams. The lightest of all the soils of the table is the sediment loam ("slickens") from Sacramento, derived from the tailings from the placer mines of the foothills. It has a weight of only 76.4 grams per 100 ccm., a little less than that of the red ferruginous soil of Grass Valley, which contains 53 per cent of (highly ferruginous) clay.

We thus have altogether very great differences of weight among the soils presented in the table; and this necessarily implies great differences in volume for equal weights of the respective soils. The very light silts would have a volume very much greater than soils of coarse sand, such as the Morano specimen; and the total amount or volume of space between the grains would be correspondingly larger. The capacity for water would thus be greater in the light soils than in the heavy, if such capacity were dependent entirely upon the interspaces. We find such to be the case in the present series of analyses, and soils which should

naturally be rather low in the scale of comparisons, rise to the first place because of this increase of volume, weight for weight. For instance, the sediment soil No. 10 from Sacramento, is the lightest of all of the soils, and 100 grams occupied a volume probably twice that of the Morano sandy soil; we naturally find, therefore, a capacity of 82 as against 23 for the latter (see table, page 89). On the other hand, if we were to take the water-capacity of equal *volumes* as the unit of comparison, we will have a basis much less subject to variations and consequent errors, though not entirely so. It is altogether the safer of the two, and though both comparisons are given in the following discussion, that by volume takes precedence; the more, as it has the most direct relation to practice.

Changes in Volume.—When in the determinations in the brass sieve-box dry sandy soils have their lower surfaces dipped in water there is usually a sudden flashing of the water over the upper surface because of the rapid rise, and the volume remains about the same. In the more clayey soils, however, the rise is slower, and the appearance of the water on the surface is more irregular, and a longer time is required for complete saturation. In the ferruginous soils, and in some of the loams, there is seen a contraction along the edges just before the water reaches the surface, leaving an open space of about one millimeter; but when fully wet this in most cases closes up and a further expansion may cause the surface to rise above the level of the containing sieve-box. On the other hand, some of the soils were found to contract because of the puddling of their flocculated particles.

A prominent example of expansion is the "*dry bog*" *soil* of Tulare Lake, No. 77; it absorbed water with extreme slowness, and not until after twelve hours was it found to be fully saturated. Its volume had then increased until its surface had reached a height of about three millimeters above the level of the sieve-box, or nearly one third of its previous height. Other soils were also found to increase in volume, though not to the same extent.

On the other hand, we have a most interesting example of contraction in the *Tulare alkali soil*. A sample of the naturally moist though air-dried soil was taken for the test. As soon as the water began to rise from below there was the appearance of large cracks across the upper surface, and the mass began to crumple or fall together as soon as the water appeared on top. When full saturation is accomplished the soil appears as a mass of mush whose surface is some three millimeters *below* its former level. The immediate cause of this puddling and contraction is clearly the effect of the black alkali or carbonate of soda, which had destroyed the cause or causes by which the soil was kept in a flocculated condition. Another sample of the alkali soil which had been deprived of the carbonate of soda by treatment with a gypsum solution and leaching was found to act in the same manner. The soil it would seem, had not had time to recover its flocculated condition. To test this point a sample of soil was used from the original alkali tract which had been reclaimed by the application of gypsum and subsequently placed in cultivation and exposure to weathering, and upon which a fine crop of grain had been produced. The result was that the soil retained its original volume on wetting in the sieve-box, and there was no perceptible contraction; thus indicating a re-flocculation of its particles from natural causes.

MECHANICAL ANALYSES ARRANGED ACCORDING TO WATER-CAPACITY.

No.	Name.	Locality.	Hygroscopic Moisture	Water-Capacity by Volume	Mechanical Analysis.						Chemical Analysis.		Weight of 100 c.c. (6.1 cub. ins.) of Soil.	No.
					Clay.	Clay Combined with Silts. To 0.25 mm.	To 5 mm.	To 1 mm.	To 2 mm.	Sand.	Soluble Silicates	Soluble Matter.		
	CLAYS.												Grams.*	
77	Dry bog soil	Tulare Lake	10.38	76.7	29.79	45.2	47.4	55.6	64.2	22.1	18.0	34.0	111	77
643	Black waxy soil	Colton Ranch	13.51	68.0	43.54	79.1	81.7	84.8	87.5	7.2	28.4	39.5	105	643
68	Adobe soil	Chinese Camp	11.19	64.0	26.10	62.5	65.5	70.3	76.3	21.4	34.2	43.2	107	68
9	Alkali soil	Stockton	2.63	63.9	24.60	54.0	63.5	69.7	75.9	21.7	.....	.....	108	9
6	Black adobe soil	Stockton	14.53	60.9	32.63	74.0	79.5	85.1	87.1	9.1	22.3	29.1	110	6
789	Upland adobe soil	Mission San José	9.74	60.8	34.16	54.0	56.6	58.1	61.7	33.1	15.0	18.8	105	789
188	Red mountain soil	Sonoma	13.70	58.3	52.24	67.9	71.8	77.9	82.4	14.4	26.9	52.9	97	188
1	Black adobe soil	University	7.52	58.0	31.93	57.7	61.1	65.9	73.4	22.9	16.7	21.4	91	1
8	Non-alkali soil	Stockton	9.18	55.6	20.80	56.1	62.7	68.3	75.6	20.8	.....	.....	107	8
676	Volcanic soil	Clear Lake	11.11	55.0	29.84	61.2	64.9	70.9	76.9	21.9	.....	.....	101	676
863	Red soil	Grass Valley	14.20	53.7	24.78	57.1	59.5	65.3	71.0	26.2	54.0	62.3	78	863
110	Alluvial soil	Putah Creek	10.32	53.4	31.49	76.8	80.4	85.4	89.8	5.4	20.7	28.7	102	110
2	Black adobe soil	University	5.14	53.2	33.53	61.7	67.6	74.6	81.0	14.0	24.1	31.3	101	2
1679	Adobe soil	University	11.98	50.4	44.27	69.6	73.2	77.7	83.1	12.4	.....	.....	110	1679
506	Colorado bottom soil	Colorado River	9.26	48.4	23.97	55.8	67.1	79.7	88.1	3.6	16.4	37.0	86	506
1655	Red vineyard soil	Crabbs, Oakville	4.25	47.4	21.73	58.5	63.0	68.5	75.7	21.1	19.1	26.8	107	1655
986	Sandy adobe soil	Cupertino	5.10	46.6	20.54	48.2	52.1	55.6	59.9	36.8	13.2	19.9	111	986
	CLAY LOAMS.													
1645	Alluvial soil	Kells, Yuba City	5.27	59.9	15.30	58.8	68.9	77.1	85.4	12.7	23.7	32.4	103	1645
67	Mining slum soil	Chinese Camp	10.26	53.9	18.47	46.7	54.9	65.5	77.5	18.7	18.1	27.4	106	67
1663	Red mesa soil	Riverside	5.06	53.2	19.37	37.2	41.4	53.6	72.1	25.6	.....	.....	111	1663
1647	Redwood soil	Guerneville	5.14	52.3	16.54	37.0	40.4	44.5	51.7	45.2	18.4	24.2	103	1647
1113	Red foothill soil	Amador	6.00	49.6	16.43	51.3	61.3	69.0	77.2	20.0	23.8	35.3	98	1113
4	Adobe ridge soil	University	5.18	49.0	18.92	41.0	47.8	57.2	63.8	32.1	11.0	15.0	105	4
168	Valley silt soil	Santa Paula	5.49	46.4	15.02	30.2	35.3	43.3	56.0	45.5	8.6	11.9	131	168
	LOAMS.													
10	Sediment soil	Sacramento	9.18	63.0	12.06	55.6	68.7	82.4	92.7	3.5	25.1	31.4	76	10
1284	Moist land soil	Chino Ranch	5.81	60.2	13.44	35.5	40.4	46.4	59.9	35.9	13.6	28.8	102	1284
586	Plains soil	Outside Creek	4.86	49.8	10.48	34.9	37.1	47.7	53.9	43.3	16.5	22.2	105	586
1115	Granitic soil	Amador	5.93	48.9	11.86	32.8	36.1	40.0	45.9	52.2	21.0	26.3	91	1115
51	Red foothill soil	Auburn	3.17	48.4	13.91	45.8	51.4	62.8	78.8	14.9	18.2	31.6	97	51

130	Reddish loam	San Gabriel Valley	2.30	45.0	10.70	27.3	33.9	39.0	46.1	50.4	13.1	19.4	113	130
1167	Black lands soil	Tulare	5.38	44.4	14.65	38.9	44.4	47.9	54.9	42.6	16.2	21.2	106	1167
1055	Red sandy loam	Fresno	3.62	44.2	11.01	29.9	36.4	44.9	57.6	42.4	13.4	20.9	120	1055
1678	Sandy alkali soil	Tulare	6.41	33.0	10.42	45.3	48.1	54.6	62.3	31.5	.....	.....	96	1678
	SANDY LOAMS.													
1281	Mesa soil	Chino Ranch	1.98	44.7	7.60	26.1	31.6	35.5	41.9	50.8	13.4	22.5	118	1281
1159	Sandy plains soil	Tulare	4.00	43.6	5.71	16.7	20.8	26.3	33.4	63.7	13.7	20.6	116	1159
1147	Sandy loam soil	Paso Robles	1.84	37.1	7.40	25.2	31.2	39.8	48.2	50.5	5.8	9.6	129	1147
47	Red mesa soil	National Ranch	2.30	22.9	9.66	21.0	24.2	28.0	33.9	65.1	9.6	13.3	.....	47
	SANDY SOILS.													
1148	Swale soil	Paso Robles	3.43	44.4	3.09	24.6	27.8	38.1	45.9	51.6	6.7	10.0	107	1148
1197	Gila bottom soil	Gila River	3.48	42.3	3.21	8.7	10.7	13.9	24.1	72.1	8.9	23.1	124	1197
1595	Sandy soil	Castroville	1.15	37.6	2.60	8.9	9.2	12.7	13.6	83.6	.....	.....	127	1595
233	Sandy soil	Morano	.79	37.5	2.82	5.2	6.0	6.5	8.7	89.9	.....	.....	157	233

*100 grams is equivalent to about 3.5 ounces avoirdupois.

A practical lesson from this experiment is that in the reclamation of alkali lands, the mere application of gypsum will not alone restore the soil to its former tilth, but that the restoration of its flocculated condition by time and by tillage is all-important.

Comparison of Results.—In the accompanying table the soils are arranged in each group in the order of water-capacity by volume. A summary of mechanical ingredients and chemical composition and of hygroscopic moisture, is given, together with the weight of 100 cubic centimeters of each air-dried soil.

It might naturally be expected that the proportion of colloid "clay" in a soil would govern the amount of water held within its pores, and to a certain extent this seems to be the case, but is by no means a consistent rule. In fact, a study of the tables shows that we cannot rely upon this material as a basis, for many of the loams have higher capacities than the clay soils, and even the sandy swale soil of Paso Robles with its 3 per cent of clay holds more water than the soil of Cupertino with its 20 per cent. Again, the Tulare dry bog soil with about 30 of clay holds nearly 77 of water, while the Sonoma red mountain soil with 52 of clay holds but about 58 of water. In fact there are in the table nine soils which with a greater amount of clay hold far less water than the "dry bog" soil, No. 77, with only 29.8 of clay. Such instances could be cited in large number from this table alone; and to rearrange the table without groupings, so that the figures in the column of clay should read consecutively from highest to lowest parallel with the water-capacities, there would be required a movement through 200 points.

In the sixteen *clay soils* of the table, or soils having above 20 per cent of clay, the percentages run from 20 to as much as 52 of clay, the average being 31.1; while the water-capacity is from 46.6 to 76.7, with an average of 57.3. The soil having the highest water-capacity is that of the "dry bog" of the old border of Tulare Lake. Water when applied to it passed upward with extreme slowness, requiring twenty-four hours for complete saturation; in the meantime the volume had increased greatly by expansion. The high water-capacity is evidently not due to its "clay" and fine silt, for these are relatively small when compared to soils of a lower capacity. Neither is it especially rich in soluble matter, or even in humus, which doubtless has much influence in this as well as many other soils of high capacity. It may be due, in part at least, to the increase in volume, which of course adds that much to the interspaces and permits the absorption of more water; but what causes the increase in volume?

The same is true of the two soils which stand next in order of highest capacity, the adobe of Colton ranch, No. 643, and the adobe of Chinese Camp, No. 68, whose expansion was each fully two millimeters above the level of the sieve-box. The alkali soil of Stockton, No. 9, which ranks next, also expanded somewhat, but not to the same extent as the others.

In mechanical composition these last two soils (the Chinese Camp adobe and the Stockton alkali) are almost identical, except that the former has a little more clay; we find that they have almost the same water-capacity. In other clay soils, however, where the mechanical composition is very nearly the same, we find large differences in capacity, evidently from other causes. On the other hand, there are soils

having the same capacities (red mountain soil of Sonoma and the University adobe), which differ widely in composition, both mechanical and chemical; thus showing plainly that the mechanical composition, as our analyses thus far define it, does not alone govern the capacity of a soil to absorb water.

The seven *clay loams* have water-capacities varying from 59.9, the highest, to 46.4, the lowest, the average being 52 per cent. They have an average of 17.2 of clay, and although all are lower in clay than the clay soils, we find all but one having a water-capacity greater than some of the latter.

The Sacramento alluvial soil of Kells, near Yuba City, has the largest capacity (59.9) of the group, and is above the majority of clay soils in this regard. The reason for this is not immediately apparent, for the proportion of fine earth is not relatively high; it may, as in other cases, rest with the soluble silicates.

The ordinary *loams* have clays running from 10.4 to 14.7, with a general average of 12 per cent; their water-capacities are from 33.0 to 63.2, the average being 49.6. It is thus an incongruous group so far as water-capacity is concerned. It is interesting to note that the sediment soil from Sacramento, with only 12 per cent of clay, has a capacity of 63.0, or far above the clay soils, whose clays are nearly three times as great in amount. According to its chemical analysis it is very rich in hydrous silicates, probably 35 per cent, and to this it doubtless owes its high capacity for holding water.

The naturally moist soil, No. 1284, of the South California Station, Los Angeles County, is also above the majority of the clay soils in water-capacity. It contains some 29 per cent of soluble silicates and quite a large amount of humus (2 per cent), which must have some influence.

The *sandy loams*, with from 5.7 to 9.6 per cent of clay, have an average water-capacity of 30, or from 22 to 37.1. Some of them are above the ordinary loams in this respect, but none worthy of special note.

The *sandy soils*, with less than 5 per cent of clay, are fully equal in water-capacity to the more loamy specimens of the preceding group, and one of them, the swale soil of Paso Robles Station, stands above several of the loams proper with more than 10 per cent of clay. The Morano specimen, No. 233, which may be regarded as a typical sandy soil, with nearly 93 per cent of sand and coarse silt, will hold but 37.5 per cent of water, and this is the lowest in capacity, except two, in the entire list of forty-one soils. The exceptions are the sandy loam of Paso Robles and the red mesa soil, No. 47, of San Diego County, which though having about 10 per cent of clay, each have capacities of but 37.1 and 21.9, respectively. The reason for this is not yet clear.

The proportion between the clay and the finest silts affects very greatly the water-capacity, for when the former is in quantity just sufficient to bind the particles of silt when wet, it will produce what is known as "putty soils." A larger amount of clay affords an excess above what is needed for binding, and this excess of flocculation among its particles tends to break this union and produce looseness. The swale soil, No. 1148, from the experiment station at Paso Robles, is an instance of these putty soils. It is made up of 42.8 of silt, 49.9 of sand, and but 3.09 per cent of colloid clay, and would therefore naturally be placed among the sandy soils; but the proportion of clay is just sufficient to fill the interspaces of the silt, and when wetted, cause these to

closely adhere, producing a putty condition while wet, and a compact, solid, rock-like mass when dry. (The sample of this soil, 3x4x36 inches, taken in this latter condition for the World's Fair, reached us from the return trip across the continent in the same solid form, while the other samples were much broken up.) When wet it packs closely and naturally retains more moisture than if it were a little more porous; it forms "boggy" tracts dangerous to teams. The Gila River soil, No. 1197, has very nearly the same amount of clay, but its proportion of silt is less and that of coarser sand much greater; we do not, therefore, find the same adhesiveness among the particles, nor the peculiar properties when wet.

WATER-CAPACITY BY WEIGHT.

Two methods were used in the determination of water-capacity by weight. That at first employed has proven to be unreliable and has been discarded for the newer method. In it, 100 grams of air-dried soil was placed into a funnel containing a filter (whose average water-capacity had previously been ascertained), and water allowed to flow on top from a graduated pipette until thorough saturation or until it passed through, the excess from drippings being returned to the pipette; the amount of water was thus quickly determined. It was found that the method was open to serious and even fatal errors. First, the height of the column of soil in the filter, 30 to 50 millimeters, was so great as to create serious errors, due to the differences in total capillary ascent, to which the conical column in the funnel bears no sensibly constant ratio. Second, the filter, itself a source of error, also acted as a carrier for the water when, by reason of physical or chemical properties in the soil, percolation was very slow, and thus full saturation in the center of the soil was prevented. In a number of soils the water-capacity is found to be greater than by the newer method, the reason for which is not apparent, but perhaps due to the filter. The results by this method are given in the table below for comparison with that by other methods. The method now used is that of the sieve, suggested by Professor Hilgard in the determinations by volume, by which the saturation is accomplished by capillary ascent of the water, in a column of soil 10 millimeters high. Results are given in the following table:

WATER-CAPACITY BY WEIGHT.

Number	Name.	Locality.	Water-Capacity Percentage.			Weight of 100 Cubic Centimeters of Soil.
			By Weight.		By Volume.	
			Sieve.	Funnel.	Sieve.	
	CLAY SOILS.					Grams.
77	Dry bog soil	Tulare Lake	68.9	79.6	76.7	111
863	Red soil	Grass Valley	68.8	61.4	53.7	78
643	Black adobe	Colton Ranch	64.6	70.3	68.0	105
1	Black adobe	University	63.5	61.4	58.0	91
68	Adobe soil	Chinese Camp	59.8	70.8	64.0	107
188	Red mountain soil	Sonoma	59.6	44.9	58.3	97
9	Alkali soil	Stockton	58.9	64.0	63.9	108
789	Upland adobe	Mission San José	57.8	50.7	60.8	105
506	Bottom soil	Colorado River	55.6	46.5	48.4	86
6	Adobe soil	Stockton	54.9	47.1	60.9	110
676	Volcanic soil	Clear Lake	54.4		55.0	101
2	Black adobe subsoil	University	52.4	46.0	53.2	101
110	Alluvial soil	Putah Creek	52.4	50.0	53.4	102
8	Non-alkali soil	Stockton	52.1	54.0	55.6	107
1679	Adobe soil	University	46.0	44.4	50.4	110
1655	Red vineyard soil	Crabbs, Oakville	44.3	45.0	47.4	107
986	Sandy adobe	Cupertino	42.0	39.0	46.6	111
	CLAY LOAMS.					
1645	Alluvial soil	Kells, Yuba City	58.4	44.3	59.9	103
1113	Red soil	Foothill Expt. Sta.	52.3	47.5	49.6	98
67	Mining slum soil	Chinese Camp	50.7	52.2	53.9	106
1647	Redwood soil	Guerneville	49.9	45.0	52.3	104
1663	Red mesa soil	Riverside	48.0	42.6	53.2	111
4	Adobe ridge subsoil	University	46.6	45.7	49.0	105
168	Valley silt soil	Santa Paula	38.7	33.1	46.4	131
	LOAMS.					
10	Sediment soil	Sacramento	82.3	63.2	63.0	76
1284	Moist land soil	Chino Ranch	58.8	54.7	60.2	102
1115	Granitic soil	Foothill Expt. Sta.	53.8	42.5	48.9	91
51	Red soil	Auburn	49.7	45.3	48.4	97
586	Plains soil	Outside Creek	47.3	34.2	49.8	105
1167	Black lands soil	Tulare	41.7	38.3	44.4	106
130	Reddish loam	San Gabriel Valley	40.7	39.7	45 0	113
1055	Red sandy loam	Fresno	36.9	39.6	44.2	120
1678	Alkali loam	Tulare	34.2	32.0	33.0	96
	SANDY LOAMS.					
1281	Mesa soil	So. Cal. Expt. Sta.	37.9	33.4	44.7	118
1159	Sandy plains soil	Tulare	37.4	36.5	43.6	116
1147	Sandy loam	Paso Robles Expt. Sta.	28.7	28.5	37.1	129
47	Red mesa soil	National Ranch		21.9	22.9	
	SANDY SOILS.					
1148	Swale soil	Paso Robles	41.5	40.9	44.4	107
1197	Bottom soil	Gila River	34.8	32.0	42.3	124
1595	Sandy soil	Castroville	29.7	31.2	37.6	127
233	Coarse sandy soil	Morano	23.0	24.3	37.5	157

Soils of Light Volume-Weight.—It will be seen by comparison with the former table, that in nine soils the capacity by weight is greater than that by volume, and that in each of these the reason lies in the fact that the soil is light in weight, giving greater bulk weight for weight; and while the actual amount of water by volume is not affected, the percentages calculated upon the soil weight is greater than if the soil were heavier. The weight of the soil is, in all these cases, less than 100 grams per 100 cubic centimeters; all other soils are above that in weight.

Again, the lightest soils have the greatest differences between capacity by volume and that by weight. In the sediment soil of Sacramento, the lightest of the series, and which has the highest capacity by weight, the difference is 19; in the red soil of Grass Valley, the weight of which is a little greater, the difference is 14; the bottom soil of the Colorado River, the next in weight, has a difference of 7 per cent; and the University adobe, No. 1, and granitic soil of the foothills, having the same weight, have also the same differences of 5 per cent; the others of the group of nine are less than this.

Change of Relative Position.—It will also be noticed that in the order of arrangement from highest to lowest, the relative positions of many of the soils in the clay, clay loam, and loam groups have been changed from that of the table of percentages by volume. The dry bog soil, No. 77, maintains the first place, the Grass Valley soil becomes second instead of eleventh, the University adobe fourth instead of eighth; the reasons have already been given. In the sandy loams and sandy soils the order of position remains the same.

Collapse Caused in Alkali Soils.—It is worthy of note here that when water was applied to the dry bog soil No. 77, in the funnel, several hours elapsed before it appeared below, and that the mass finally became a fine mush, quite in contrast to its condition when saturation was effected by capillary water from below in the sieve. This mushy condition assumed with water, is due to the puddling of the particles of earth, a breaking up of their flocculated condition, and precipitation into a mass so compact as to prevent the percolation of water. This phenomenon is due to the presence of ("black") alkali or carbonate of soda in the soil, as shown by the chemical analysis, and is characteristic of all such alkali soils, and by which are produced the hog-wallows or swales on the surface of spots thus affected.

Direct experiments to determine the changes caused by such puddling of clay, by means of carbonate of soda, in other soils, will be made in the near future.

Conclusion.—Without closely comparing the results of the above table it may be remarked that while in some the water-capacity seems to be largely controlled by the amount of fine material (clay and silts); there are others affected chiefly by other causes, for, while their water-capacity is practically the same, they differ very greatly in mechanical composition, as is also shown when considering the capacity by volume. Thus the sandy swale soil of Paso Robles, with its 3 per cent of clay, has about the same capacity as the Cupertino sandy adobe with its 20 per cent of clay; neither is there much difference in weight of the two soils. The alkali soil of Stockton and the Chino moist land soil have about the same capacity, and yet the one has nearly twice as much clay and much more fine earth than the other; there is again but a slight difference in volume-weight.

As a class, the clay loams, with from 15 to 20 per cent of clay, equal and in few cases surpass in capacity the majority of clays with from 20 to 29.8 of clay. The ordinary loams in turn, with only 10 to 15 of clay, equal the clay loams, and in two of the soils surpass them in capacity.

So that altogether, whether we estimate the water-capacity with reference to volume or to weight, we arrive at the same conclusion, viz., that the capacity of a soil to hold water is not alone controlled by the amount of the clay and fine material that enter into its composition, but

that the character of that clay and silt, both chemical and physical, and the presence of certain compounds, exercise a very large, and in most cases, a controlling influence.

In considering a number of the extreme cases in point we are led to the suggestion that the hydrous silicates (and other hydrates) other than clay are intimately concerned with this property, and that the important part which they play, from a chemical point of view, as repositories of plant food, appears to be supplemented by a no less important influence upon the physical characters of the soil.

THE CAPILLARY RISE OF WATER IN SOILS.

The height to which water will rise by capillary movement in soils from underground irrigation water, and the ease with which it is thus transmitted in all directions, is a matter of vital importance to all vegetable growth, especially in regions of scanty rainfall. This property in a soil is dependent largely upon its physical condition, and as it is sandy, silty, loamy, or clayey, the water has a greater or less freedom of movement in all directions.

It is well known that water percolates through a sandy soil with greater ease and rapidity than through silt or clay, because of its more open character, and the consequent less resistance offered by friction. Clays, on the contrary (unless the particles are in a flocculated condition, thus presenting open interspaces), are so closely united as to afford but little opportunity for the passage of water. Then, too, the strong attraction of clay for water and the very high tenacity with which it holds on to that first absorbed, renders it almost impossible for a column of water to force its way rapidly downward to lower depths, or to either side.

The same is true of the next material, the silts, but to a less degree, and is largely governed by the chemical nature; a silty soil of extreme resistance to the passage of water has already been alluded to on page 81. The downward movement is naturally the greatest and most rapid; the lateral is less so, while that upward is the slowest of all, and its limit, as well as rapidity, is controlled by the physical and to some extent by the chemical character of the soil.

The capillary power in a soil, or that power which draws liquids upward against the opposing or downward force of gravity, is governed by the size of the spaces between the particles. This is of course greater in sandy than in clayey soils, and even in loams, where the spaces between the sand grains are filled with those of clay. In the former there is greater freedom of motion, but also a smaller tension of the relatively large water surfaces in the interspaces; hence we find that in these soils, while rising rapidly, the capillary water may not reach more than a few inches in height. In loam and clayey soils in which these surfaces are not so large, but their tension greater, the height to which the water ultimately rises is far greater, though in consequence of friction, much slower. The extreme height thus far attained in the experiments made is 50 inches, even after a period of 225 days.

Method of Examination.—The old method of using a glass tube has been changed to that of copper tubes one inch in diameter, in sections of 12 inches, made to fit together; one side of the tube left open and flattened to receive a piece of glass plate, which is held in position by rubber

bands and made tight to the tube by paraffine to prevent sifting of the soil. Three objects are thus gained: any length of tube can be used by simple adjustments, the soil can be properly filled in, and, when the experiment has been completed, an examination of any portion of the soil column can be made to ascertain the percentage of water held at different heights above the surface, or for other objects. A muslin cloth is fastened over the lower end of the tube to prevent escape of the silt, and the tube is ready for filling.

The filling-in of the soil requires care and special precautions, for it is found that if it is simply poured in from the top, the soil adjusts itself in irregular layers by levigation, the larger particles arriving before the lighter ones, and thus producing segregation into layers, and that the water rises irregularly and presents a very irregular and zigzag horizontal line, and thus preventing close reading. This irregularity is largely prevented by the use of a stiff wire, the lower part bent into a corkscrew spiral 6 or 8 inches long and nearly of the diameter of the tube itself. The soil is poured into the tube in successive portions, each filling it to the top of the wire spiral, which is then turned as if to make it enter, but at the same time gradually withdrawn; this thoroughly breaks up any tendency to stratification and leaves it in a uniform condition. A column of about 30 inches is thus prepared and somewhat tamped by slight tapping on the table. If necessary, other tubes may be added and filled later in the experiment, as the water rises. A graduated scale is then attached to the side of the tube, which is placed upright on a perforated bridge in a water reservoir; the latter is then filled with water to the zero point of the scale. Frequent readings of the rising water-line are then made and recorded.

The soils selected for the experiment were of distinct physical characteristics, and the examinations were made at different times; the results of some of them have already been given in the Report for 1892, but are reproduced here for convenience of comparison with those more recently made. They comprise the following:

No. 1197, bottom alluvial soil of Gila River.

No. 233, sandy soil of Morano, Stanislaus County.

No. 168, silty soil of Santa Paula, Ventura County. This was tested in both the tilled and the tamped condition.

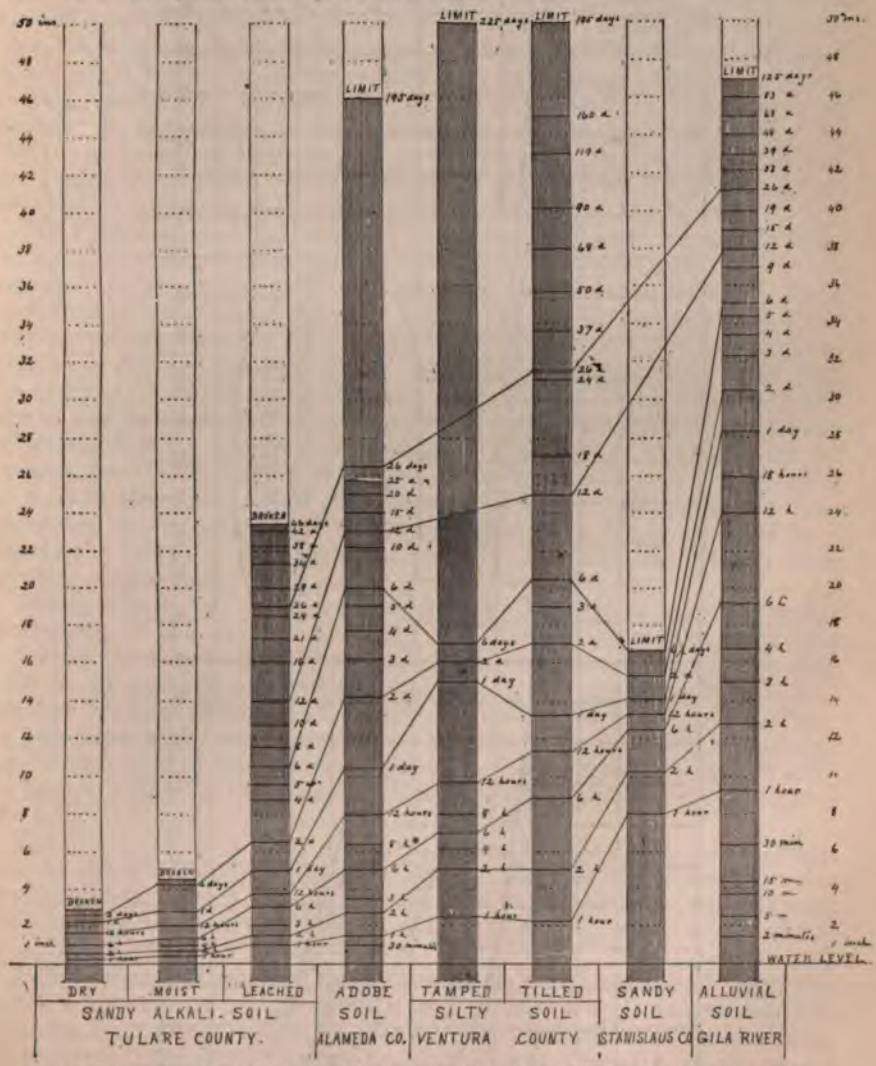
No. 1679, adobe soil from the University grounds, Berkeley, Alameda County.

No. 1678, sandy alkali soil from Tulare. This was tested first in its natural or moist condition, then when dry, and then after its alkali had been changed to the sulphate by treatment with gypsum solution and leached out.

The following table gives the percentage of mechanical ingredients forming each soil:

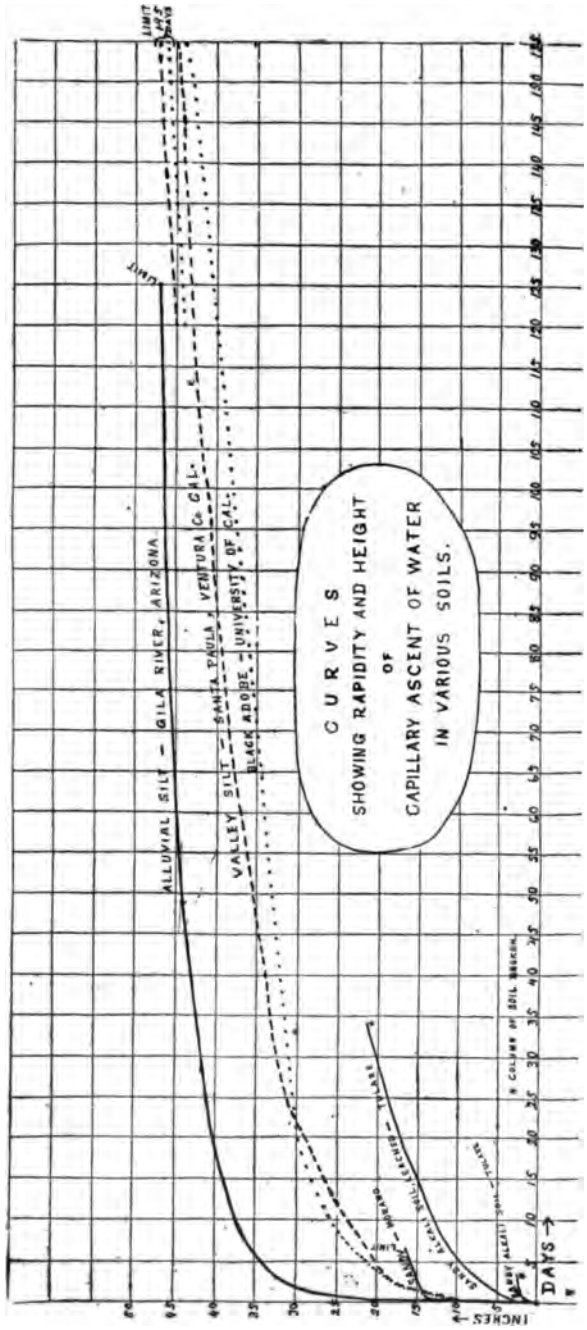
	Clay.	Silt.		Sand.
		Fine.	Coarse.	
No. 1197. Gila bottom soil	3.21	5.53	15.42	72.05
No. 233. Morano sandy soil	2.82	3.03	3.49	89.25
No. 168. Ventura silty soil	15.02	15.24	25.84	45.41
No. 1679. Berkeley adobe	44.27	25.35	13.47	13.37
No. 1678. Tulare sandy alkali soil	10.42	24.81	16.96	41.62

The accompanying diagram represents the upright columns of soil, marked to show the rapidity with which the water rose in each column, and the extreme height attained. The columns are arranged from right to left in the order of rapidity of ascension, and the lines connecting the points of equal heights serve to enable the eye to quickly take in the variations. Unfortunately in the early experiments with three of the columns (Alameda and Ventura soils) no time record was kept of the higher portions of the columns, and comparisons cannot be made with these. All of the samples were air-dried when placed in the tubes, except that one of the alkali columns was deprived of its natural moisture by drying at 100° for comparison with the moist column. The columns are shaded to the point reached by the water.



Columns showing heights to which water will rise by capillarity in soils of different physical composition.

Graphic Curves.—Another method of illustrating the differences in rate of ascent of water in the several soils is that of curves through spaces in which the vertical represent equal heights in inches, and the horizontal spaces represent length of time in days, as shown in the accompanying cut.



The alluvial soil of Gila River, because of the very great rapidity of ascent on the first day, stands above all the others; the Ventura silt next, having crossed the path of the adobe after 20 days. The alkali soil is lowest of all in the scale, doubtless in consequence of the infinitesmal subdivision of its particles by puddling, and the total absence of flocculated structure due to the presence of sodic carbonate.

COMPARISON OF THE RAPIDITY OF WATER-ASCENT IN THE SOILS.

The Gila River alluvial and the sandy Morano soils are each very sandy, and the water, finding but little clay to obstruct its passage, rises very rapidly for a certain distance in each. The relatively large water-mass between the grains of sand in the Morano soil, however, yields to the force of gravity, and the water soon ceases to rise. In the Gila soil, however, these spaces between the coarse particles are filled with 21 per cent of silt (only 6.5 in the Morano), and thus by making a smaller tension-surface (meniscus) between the grains, the capillary force remains superior to that which pulls downward, and the water is enabled to rise to the height of 47 inches above water-level. In the Gila River soil the grains of sand are not as coarse as in the Morano sample, and this also has its influence in increasing the capillarity of the former.

The Tulare sandy alkali soil and the Ventura silty soil are nearly alike in physical composition, and should therefore have about the same capillary power, if the mere soil particles are to be considered. They each contain practically the same amount of silt (41 per cent), and the clay in each is not very high. The differences in capillarity are, however, very great at the intervals of time recorded, and clearly show that the power in a soil to transmit water upward is not entirely due to the size of the particles, but to other causes, such as probably the presence of certain soluble salts which change the condition of the soil. In the present instance the retarding effect of the small per cent of carbonate of soda in the alkali soil is plainly seen. Had the column not broken, the water in the alkali soil would probably have finally reached very nearly the height of fifty inches attained by the silty soil, though after a much longer time.

Sandy Alkali Soil.—The column having the slowest capillary water movement is the dry, sandy alkali soil from Tulare. The dark line marking the ascent of water reached the water-level from below only after many minutes had passed; and then at the end of an hour it had reached a height of one fourth of an inch, and in six hours only an inch. In two days, when the column broke because of the puddling of the clay and contraction of the wet mass, the water had reached a height of only $2\frac{3}{4}$ inches, and even then only after repeated trials of a fresh column of the soil.

The moist alkali behaved somewhat better, but also broke in two days, at a height of $4\frac{1}{2}$ inches above water-level. The rise was somewhat more rapid than in the dry sample, though still extremely slow, reaching an inch only at four and one half hours after it had appeared at the water-level in the reservoir.

To see what influence, if any, the soluble alkali salts had upon the upward movement of the water, a sample of the soil was thoroughly leached, and thus freed from alkali, was dried and put in the tube. Improvement was very perceptible, though not specially so; the water

rose seven eighths of an inch in an hour, and 6½ inches in two days—about 2 inches more than in the moist unleached condition.

A marked feature of the experiment was the fact that the column of the leached soil held for 46 days before a break came; in strong contrast to the two columns of unleached alkali soil, each of which broke in two days. This breakage is caused by the puddling of the soil, by which the particles are released from their flocculated (coalesced into small masses) condition and caused to fall together in a more compact form. This is a prominent characteristic of all alkali soils, and is the effect of the black alkali (carbonate of soda).

The phenomenon seen in a tube is entirely parallel to that observed in every natural "black alkali" spot, which invariably shows a material sinking of the surface below the general level of the surrounding land, and becomes consolidated into sheets of tough hardpan.

The extreme limit of upward capillary movement in this soil was not ascertained, because of the break in the column; but a comparison of its rate of ascent with that of other soils of somewhat similar composition, shows that it is hardly probable that the water-line would have risen higher than 40 inches even in 200 days.

Black Adobe Soil.—The close, heavy-clay character of this soil made the upward movement of water a very slow one, and in one hour the dark line marking its rise had reached but 1½ inches. In twelve hours it had risen but 8 inches, and required twelve hours more to reach 10½ inches. The movement then became very slow, and on the twenty-sixth day, when the detailed record ceased, it had risen but 26 inches, and 195 days were required for it to reach its limit of 46 inches.

Silty Soil.—The silty soil of Ventura County was tested in two conditions, the tamped or compact, and the loose, friable form as given by tillage, in order to ascertain the effect of each upon the capillary power. Unfortunately no record was kept of the rise of the water in the tamped soil after the sixth day. A comparison of the record of each column during the six days is quite interesting, for a glance shows the greater freedom of movement that existed in the loose tilled soil above that of the tamped. The entire height reached was the same in each, 50 inches, but the time required was 195 days for the tilled against 225 for the tamped. For the first two hours the rise of the water was about equal, but at the end of the sixth hour the line marking the limit was 3½ inches higher in the tilled soil. At the end of one day the rise was about even again at 13 inches, doubtless because of some irregularity in the tamping, but afterward the tilled soil again took the lead and kept it so far as the record shows. On the sixth day the difference was 5½ inches.

Sandy Soil.—The sandy soil of Morano, Stanislaus County, showed a rapid rise of 8 inches in one hour, but afterward the rate diminished rapidly, and in six and one half days it had reached its extreme limit of 16½ inches. The spaces between the grains in this soil are so large that the capillary tension that causes the water to rise is soon stopped by the force of gravity, and no further movement occurs.

Gila Bottom Soil.—The alluvial soil of Gila River is remarkable in its power of transmitting water upward by capillary movement. The ascent was extremely rapid at the first, the water making its appearance very quickly above the water-level in the reservoir, and reaching 1½ inches in two minutes, 2½ inches in five minutes, and 6½ inches in thirty minutes.

In one hour a height of nearly 9½ inches had been reached, in two hours nearly 13 inches, in six hours 19½ inches, while at the end of twelve hours the water had risen 24 inches. At the end of a day the height reached was 27½ inches, and the movement rapidly became slower until the limit of 47 inches was reached in 125 days. This combination of sediments thus appears to be the most favorable for rapidity of ascent.

COMPARISON BY TIME-LIMITS.

To facilitate a comparison of the capillary power of the several soils, the point reached in each at the end of the several periods of time are connected by lines. A glance thus almost instantly shows the great difference, and marks those of the soils in which capillary movement is respectively at the extreme of retardation and of rapidity. We thus have the dry, sandy, alkali soil of Tulare at one, and the light, sandy, alluvial soil of Gila River at the other extreme. While the former required six hours to draw the water up one inch above water-level, the latter soil in the same time had drawn it up 19¼ inches. At the end of a day the respective heights were 2¼ and 27½ inches, while at the end of two days, when the alkali column broke, the heights were respectively 2¾ inches and 30½ inches, a difference in rapidity of about 1 to 11.

This great difference between these two soils is in part due to the presence of the carbonate of soda in the alkali, which, as already remarked, produces a puddled condition in the soil as soon as it comes in contact with water, thus preventing a more rapid rise. Other conditions than this, however, tend evidently to produce slow movement in this soil, for when the alkali has been almost entirely leached out the movement is still very slow, though not markedly so. In the first hour the rapidity was but little faster than in the unleached soil, but in the sixth it was at 3 inches as against 1¼; in one day the heights were respectively 5 and 2½ inches, while in two days they were 6½ and 4½ inches.

We must look, then, to both the mechanical and chemical compositions for causes of differences in capillary movement in soils; but in this comparison with other soils of the columns we will omit the alkali feature and take only the leached soil, in order to have all as nearly as possible on the same basis of freedom from excess of soluble salts, and thus be able to draw comparison from a mechanical point only. We thus may follow the rising water in the various types of soils, the sluggish movements in the leached alkali, the adobe, and the silty soils, with the rapidity of the sandy and the alluvial soils.

First Hour.—The water has reached barely 1 inch in the leached alkali soil, 1½ inches in the adobe, 2 inches in the silty soil, while in the sandy and the alluvial it has dashed upward with astonishing rapidity to 8 and 9½ inches, respectively.

Second Hour.—While the movement is still very sluggish in the leached alkali and the adobe, it has gained a little on their next highest competitor and lessened the relative distance between them and the sandy soil to 5 instead of 6 inches. The alluvial soil has in the meantime increased its height with greater relative rapidity and stands nearly 13 inches.

Sixth Hour.—The leached soil has carried its water-line to only 3 inches above the surface, the adobe to a little more than 6 inches, the tilled silty soil to 9 inches. In the meantime the sandy soil is becoming more

and more sluggish in its capillary power, reaching but 12½ inches, while in the Gila alluvial the water has risen rapidly to more than 19 inches.

First Day.—The extremes at the end of the first day (24 hours) are very far apart, for in the leached soil the water has reached a height of but 5 inches, while in the Gila alluvial soil we find it at 27¼ inches. In the adobe its progress upward was comparatively slow to 10½ inches, while in the silty and sandy soils the water-mark stood at 13 and 14 inches, respectively.

Second Day.—The marked feature of the several columns at the end of the second day was that the water in the Ventura silt had overtaken and risen nearly 2 inches beyond that in the sandy soil, which had nearly reached its extreme limit, but is itself 13½ inches lower than in the Gila alluvial. The height reached in the adobe and in the tamped silt is almost the same, while the leached alkali soil lags far behind and does not reach this height until the thirteenth day.

Sixth Day.—On this day the sandy soil reached its extreme limit of 16½ inches, a point 18½ inches below the alluvial of Gila River. These two results clearly show the very marked difference in capillary power between a coarse and fine sandy soil, for they each have about the same proportion of fine material; but in the sandy Morano soil the proportion of very coarse sand is much the greater, and thus presents relatively much wider spaces between the grains; a natural result is that gravity checks the upward movement quicker than in the finer sands of the Gila soil.

Twelfth Day.—At this time the water in the Ventura silt has gained on that of the adobe, and has also lessened the relative distance between itself and the alluvial of the Gila River; which shows a steady and good movement upward on the part of the Ventura silt water as against a strong slowing-down in the Gila alluvial and other soils. The distance between the limits in the adobe and the leached alkali is relatively the same as at the end of the first day.

Final Limits.—The silts, both tamped and tilled, proved to have the highest capillary ascent, the water reaching a height of 50 inches in 225 and 195 days, respectively; in these is seen the fact that tamping or allowing the soil to become hard serves to retard the rise of water, and that on the contrary, when by tillage the soil becomes loose, the rise is much more rapid, because of the greater freedom to move between the flocculated particles.

The water in the alluvial soil of the Gila River reached its extreme limit of 47 inches in 125 days, having required 42 days to pass through the last inch. Throughout its course the movement of water has been very rapid until the last few inches. In this sudden slowing-down it strongly resembles the sandy Morano soil, which came to a sudden stop early in the race because of its open, sandy nature.

In comparing the rate of ascent at the last in the Ventura silt and the Gila alluvial we notice that the water rose 5 inches in 35 days in the former as against 1 inch in the latter soil in 42 days, or as 7 to 42. There is therefore strong reason to believe that the water would have risen higher than 50 inches in the silt had a greater length of time been allowed.

The water in the adobe worked its way slowly upward until it reached its limit of 46 inches in 195 days.

PERCENTAGE OF CAPILLARY WATER AT VARIOUS HEIGHTS IN THE COLUMN.

In order to determine the amount of water held by the soil at various heights after the capillary experiment was concluded, the separate pieces of glass were removed from the front of the soil-tube, and portions of the soil transferred to the ground-stoppered weighing-tube as quickly as possible, and weighed; they were then dried at 100° and again weighed, the loss representing the amount of water held. In this manner the water in several of the columns was determined with the following percentage results:

Percentage of Water Held at Various Heights.

Height Above Water-Level.	Gila Alluvial. 1197.	Morano Sandy Soil. 233.	Adobe. 1679.
47 inches	4.33		
42 inches	10.26		
36 inches	11.99		
30 inches	15.26		
24 inches	21.39		10.26
18 inches	27.63		29.48
12 inches	32.48	3.93	33.04
6 inches	35.04	14.15	38.47
3 inches			38.94
1 inch	36.64	24.34	44.41

As was to be expected, there is a rapid decrease in amounts from below upward, but the rate was not at all uniform. In the Gila soil, for instance, there is a difference of 1.6 in the first six inches, 2.6 between six and twelve inches, 4.8 between twelve and eighteen, 6.3 between that and twenty-four, 6.1 to thirty, 3.3 to thirty-six, 1.7 to forty-two, while thence to the top there is 5.9 per cent difference or falling-off in the amount.

The same irregularity is noticed in the adobe, which for each six inches upwards reads 6, 5, 3, 19, showing in each soil at the last a sudden and great decrease in the amount of water. On examination of the adobe soil, it was found that the earth immediately above the line colored by the water had a tendency to adhere, though not wet; a sample of this was found to contain 4.47 per cent of moisture, while that which was apparently dry an inch above it had only 1.94 per cent. It would seem, then, that a large proportion of the water at the top of the column, not having reached its greatest height, had a surplus which enabled it to go further; but finally the film becomes too thin to rise any further, and the moisture above is simply from evaporation.

GENERAL CONCLUSIONS.

From the foregoing data we may draw the following conclusions in brief:

1. The power possessed by soils of absorbing moisture from the atmosphere and to hold water within their pores is not proportionate alone to the amount of combined surface presented by the particles of the soil; and while, as a *very general class*, soils with large percentages of clay and fine silts have a high moisture and water-capacity coefficient, such materials by no means control that power, simply because of large surface area; for even in the small number of soils represented in the

above analyses there are many which, though having very high clay percentages, are low in their moisture and water coefficient, and *vice versa*.

2. There are in the soil certain chemical compounds (zeolites, ferric, silicic, and aluminic hydrates and humic compounds), which are highly hygroscopic and absorptive in themselves, and are held almost exclusively by the clay in greater or less amounts. The proportion of these, singly or conjointly, seem to have a greater, if not a controlling, influence over that power than the mere amount of clay and fine material, as such.

3. The upward movement of water in soils is controlled in rapidity by the proportion of coarse material; and the limit in height to which water will rise by capillarity is dependent upon the amount of fine silt and clay. The extreme height reached thus far, under the most favorable conditions, is 50 inches, even after several months. In sandy soils the limit was less than 18 inches.

4. The presence of alkaline salts in a soil produces a puddling or deflocculation of the particles when wet, and a consequent compact condition, which prevents the rapid rise of water. This puddling is accompanied by large contraction of volume, a feature which to a far less degree has been observed in other soils. On the other hand there are some soils (adobes and certain ferruginous clays), which, when wet, expand quite considerably, because of the swelling of the colloidal particles.

THE RELATIONS OF SOILS TO CLIMATE.*

By E. W. Hilgard.

Since soils are the residual product of the action of meteorological agencies upon rocks, it is obvious that there must exist a more or less intimate relation between the soils of a region and the climatic conditions that prevail, or have prevailed therein. It is the object of this paper to discuss, both from the theoretical and practical standpoint, some of the more important phenomena dependent upon this correlation, and their effects upon the agricultural peculiarities of the chief climatic subdivisions.

In order to render this discussion intelligible to the general reader, it will be best to recapitulate, as briefly as may be, the several agencies that contribute toward the process of soil formation from rocks and their decomposition products.

THE PROCESSES OF SOIL-FORMATION.

HOW SOILS ARE FORMED.

(*a*) Mechanical Agencies.—The chief *mechanical* agencies concerned are the following, mentioned in the order in which they usually follow each other in nature:

1. Effects of *changes of temperature*, whereby the several minerals of which many rocks are composed are differently affected, so that their close adhesion is gradually weakened, and minute cracks are formed, which give access to water and air, and to the small rootlets of plants.

*Partial and revised reprint of bulletin No. 3 of the Meteorological Bureau, Department of Agriculture, 1892.

2. Effects of *freezing water*, which widen still farther the minute crevices by its irresistible expansion, and in case of the larger cracks rends rock-masses into fragments, thus increasing the surfaces exposed and facilitating the removal of the rock from its original site, whether by gravity, moving water, or wind.

3. Effects of *moving or flowing ice* (glaciers). While at present confined to relatively limited areas, yet the powerful action of glaciers in grinding rocks to fine powder, from which soils form with great rapidity, renders this agency of great importance, even at the present time; while in the past, the enormous areas known to have been glaciated are covered largely with soils produced by this process conjointly with that of the water resulting from the melting of the ice. The rocks carried on the surface of glaciers are subject in the highest degree to the effects of changes of temperature, becoming intensely heated during clear days by the sun's rays when unaffected by the denser portions of the atmosphere, and at night again subjected to frost. These frequent and violent changes assist greatly the merely mechanical grinding and abrading process resulting from the ice-movement, both on the surface, within the ice-mass (in the "crevasses"), and on the lower surface, which in the course of time becomes lined with stones that score the rocky bed with deep furrows. Hence, glacier streams are always notable for the large proportion of very fine rock-powder carried by them.

4. The effects of *flowing water* are doubtless at this time the most potent agencies of soil-formation. Apart from the mere removal of loose materials from one point to another, its effects in carrying sand, gravel, and bowlders, according to velocity and volume, are prodigious. For these rock fragments not only score the bed of the stream or rill, but by their mutual attrition and abrasion produce more or less of fine powder similar to that produced by glacier action, but usually much more mixed in its ingredients, because derived from a wider range of surface. "Alluvial" soils thus formed are usually the most generalized in composition, while the "colluvial" soils of rolling uplands and slopes generally are commonly, like those derived from glaciers, more of a localized character.

5. Finally the effects of the *wind* have to be considered. To this agency very extended effects are ascribed by some which by others are attributed chiefly to aqueous action. There can be hardly any doubt about wind and wind deposits in soil-formation; for in many cases no other imaginable agency could have produced the effects observed. Such Æolian soils may either have been carried off by the wind, directly from the weatherward rock, or else soils ready formed may be taken up by the wind and carried sometimes to great distances before being deposited. The sandstorms of the arid region are a case in point. In desert regions the distinction between the regions of coarse gravel ("Hammada" of the Arabs) stands in pointed contrast to the region of shifting sand; while farthest under the wind, we find dust deposits of extreme fertility. The dunes of the sea-coast belong, of course, to the same category.

(*b*) CHEMICAL AGENCIES.—The *chemical* processes that contribute essentially to the formation of soils are these:

1. *Solution by water alone.* Since few substances known, and especially few of those forming rocks, are entirely insoluble, even in pure water, while some (like gypsum) are easily dissolved in the latter—even rain

water carries these effects with it wherever it falls. But, practically, no pure water is found in nature, and it has required the utmost refinements of apparatus and manipulation to obtain it even artificially. The impurity which it almost invariably carries is an apparently weak, but, in its ultimate effects, very powerful agent, viz.:

2. *Carbonic acid*, the acid of "soda-water," produced naturally by all processes of decay, fermentation, and slow or rapid combustion of vegetable and animal substances, coal, etc., as well as by the breathing of animals. Being contained in the air, this acid gas is absorbed in rain water, and imparts to it additional solvent properties; being continually generated in the soil by the decay of the vegetable matter, it renders the soil water a relatively strong, acid solvent, which acts steadily upon the mineral matters of the soil and decomposes them still further, rendering their ingredients available for the nutrition of plants.

3. The *oxygen of the atmosphere* is active not only as taking part in the formation of carbonic acid, but also directly in its action upon certain ingredients of rock minerals, notably the iron compounds. Most green and black minerals contain iron in a form (protoxide) which is capable of taking up more oxygen when opportunity is afforded. This occurs when carbonic acid water acts on the minerals containing the iron; the latter is then often completely eliminated in the form of "rust" (ferric hydrate), causing the minerals and rocks to change their color from green or black to yellow or reddish, and by the increase of bulk softening or pulverizing the rock; while, at the same time, the carbonic acid dissolves and carries off, in water solution, a large proportion of the other ingredients.

4. In some cases, *water* enters directly into combination with the substances present or newly formed; thus increasing the bulk of the mass and forcibly rending the original structure. This happens in the formation of clay from feldspar, of gypsum from the mineral anhydrite, in the changing of black "ferrous" minerals into rusty brown, and in numerous other cases.

Weathering and Fallowing.—Thus the combined chemical action of water, carbonic acid, and oxygen, facilitated by the mechanical pulverization of the rocks, is most potent and constantly active in disintegrating both rocks and soils. Aside from the purely mechanical action of flowing water and ice, the effects of all the above agencies are commonly comprehended under the term "weathering," and in agricultural practice, "fallowing."

CLASSIFICATION OF SOILS.

According to the predominance of the several agencies enumerated, the soils resulting from their action may be classified into three chief divisions, viz.:

1. Sedentary or Residual Soils, or soils in place; which result from the quiet action of changes of temperature, frost, etc., in pulverizing the parent rock, together with the solvent action of water charged with carbonic acid and oxygen, but without any removal from the site of the original rock.

2. Transported Soils, which have been more or less removed from their original source; prevalently by the action of water, but also by the aid of gravity and winds. They naturally subdivide into two primarily important and universally recognized subdivisions, viz.:

(*a*) *Colluvial Soils*, consisting of materials that have been transported short distances only and have not undergone any sedimentation or stratification in flowing water of watercourses, and the distribution of which bears no obvious relation to the latter. They may therefore contain debris of all sizes more or less uniformly distributed through their mass; and they form the bulk of upland and slope soils. In the regions covered by glacial drift, their materials may have come from great distances, but still the soil-mass is destitute of any definite structure, such as belongs to

(*b*) *Alluvial* or *Sediment Soils*, which have been deposited in and from flowing water, therefore occupy areas distinctly related to present or former watercourses or lakes, and have a more or less distinct stratified or bedded structure, according to the nature of the depositing current or basin. The alluvial class therefore includes all "bottom" and "second bottom" valley soils, as well as those of ancient or modern lakes and swamps.

It is hardly necessary to say that between these several classes of soils there is every degree of transition, and it is frequently a matter of choice whether a given soil shall be considered as belonging to one or the other class. This is especially true of the older alluvial soils, many of which in the course of time have virtually become upland soils by the subsidence of the water or the rising of the land and its consequent erosion into hills. The Great Plains of the West, and many of the "mesa" lands of the continental interior and Pacific Coast of America, are instances in point, and so are the ancient river terraces ("benches") now lying high above the present flood-plains.

(*c*) *The Æolian or Wind-Drift Soils* form a third class, already referred to above. While in humid climates such formations are confined to the sea-coasts, they assume great importance in the arid regions, in consequence of the extreme dryness of the land surfaces and the loose character of the characteristic soils. Even the surface conformation of extended areas is sometimes thus determined, as *e. g.* in the case of the hog-wallow lands of the Great Valley of California.

PHYSICAL NATURE OF SOILS.

Speaking in the most general terms, all soils may be considered as consisting of more or less finely powdered and decomposed *rock* (sand, silt), *clay*, and *vegetable matter*, changed to greater or less extent toward the condition of humus or vegetable mold. The relative proportions of these three principal physical constituents determine the most general classification of soils, according to their nature; as *sandy* or *light*, *clayey*, *heavy*, and *humous*. Beyond these, the degree of fineness of the rock debris, and their chemical and physical constitution, determines distinctions such as gravelly, silty, loamy, siliceous, calcareous, magnesian, ferruginous, and others of less general application, although locally often of considerable importance.

CLIMATIC FACTORS THAT MODIFY SOILS.

Influence of Temperature on Soil-Formation.—Within the ordinary limits of atmospheric temperatures, all the chemical processes active in soil-formation are intensified by high, and retarded by low temperatures,

all other conditions being equal. We can artificially imitate, and produce in a short time, by the application of high temperatures, most of the chemical changes that naturally occur in soil-formation.

This being true, we should expect that the soils of tropical regions should, broadly speaking, be more highly decomposed than those of the temperate and frigid zones. While this fact has not been actually verified by the direct comparative chemical examination of corresponding soils from the several regions, owing to the want of uniformity in methods and the fewness of such investigations in tropical countries, yet the incomparable luxuriance of the natural as well as artificial vegetation in the tropics, and the long duration of productiveness* that favors so greatly the proverbial easy-going ways and slothfulness of the population of tropical countries, offers at least presumptive evidence of the practical correctness of this induction. In other words, the fallowing action which in temperate regions takes place with comparative slowness, necessitating the early use of fertilizers on an extensive scale, has been so much more rapid and effective in the hot climates of the equatorial belt as to render available so large a proportion of the soil's intrinsic stores of plant food; so that the need of artificial fertilization is there restricted to those soils of which the parent rocks were exceptionally deficient in the mineral ingredients of special importance to plants, and that ordinarily form the essential material of fertilizers. Quartzose, magnesian, and other soils resulting from the decomposition of "simple" rocks will everywhere be poor in plant food; again, the intense decomposing or fallowing effect of tropical climates may be offset by an equally intense leaching process in consequence of copious rainfall. It is under these conditions the class of soils now designated as *laterite* soils have been formed in the inter-tropical regions and also elsewhere under corresponding influences. They have usually a glaringly red tint, due more generally to very fine diffusion of iron in consequence of repeated reductions and oxidations than to great abundance of iron compounds (*terra roxa* of Brazil), but sometimes to extraordinary percentages of iron. An example of this, apparently, occurs in the Hawaiian Islands, in the highly ferruginous soils resulting from the decomposition of the black (hornblendic) lavas that are so characteristic of the volcanic effusions of that region. The soils formed from these are sometimes so rich in ferric hydrate (iron rust) that they might well serve as iron ores elsewhere; often having from 30 to 40 per cent of that substance. But as these soils are very unretentive, though very productive at first, they are soon exhausted; the abundant rains having apparently deprived them of almost every vestige of lime, and of most of the potash contained in the original rock. To return lime to them would seem to be the first thing needful in restoring their producing powers; and the coral sand of the beaches would offer a cheap source of supply of that substance. A more detailed discussion of some of these points is given farther on.

Influence of Rainfall on Soil-Formation.—Since water is the prominent agent in the process of soil-formation, it follows that the variations in its supply—in other words, the greater or less amount of rainfall—must affect materially that process. In addition, and especially in connec-

*A special case in point is that of the fertile tract of volcanic soils extending between the cities of Guatemala and Antigua, that have been cultivated from the earliest times of settlement. When fresh these lands yielded about 75 bushels of maize. They have now fallen off to 15 to 20 bushels, but it has taken centuries to bring about this change.

tion with the rainfall, the *temperature* conditions, already referred to, and the *manner of distribution* of rains through the seasons, in connection therewith, are potent factors.

Leaching of the Land.—One of the most obvious results of an abundant rainfall is the leaching-out of the more soluble portions of the rock constituents that have been formed or set free by the process of weathering. The extent to which this leaching occurs depends, of course, largely upon the perviousness of the soil material to water; it is greatest in "leachy" soils, *i. e.*, those in which not only the surface layer, but also the substrata, are so coarsely sandy as to permit a very rapid passage of water in all directions. From this extreme, through sandy and clayey loams to heavy clay soils, there is every gradation of perviousness to almost impermeability. Whatever water falls on the latter class of soils will largely run off from the surface, hence cannot leach out of them what, in the case of "lighter" soils, is carried currently into the country drainage.

Composition of Sea Water.—The usual nature of the substances so leached out is well illustrated in the salts of sea water, which represent the generalized result of countless ages of this leaching process.

Mean Composition of Sea Water (according to Regnault).

Sodium chloride (common salt)	2.700
Potassium chloride	.070
Calcium sulphate (gypsum)	.140
Magnesium sulphate (Epsom salt)	.230
Magnesium chloride (bittern)	.360
Magnesium bromide	.002
Calcium carbonate ("limestone")	.003
Water (and loss in analysis)	96.495
	100.000

The average saline contents of sea water would thus be 3.505 per cent. In twenty-one determinations of the saline contents of the Atlantic Ocean, the percentage ranged from 3.506 to 3.710. Of this mineral residue, common salt constitutes from about 75 to over 80 per cent.

We see that most prominent among the ingredients mentioned here is common salt (sodium chloride), which forms nearly four fifths of the total solid contents. Next in quantity are the compounds of magnesium, viz.: Epsom salt and bittern, with a very small amount of the bromine compound. Next come the compounds of calcium (lime), of which gypsum is the more abundant; while the carbonate, so abundant on the land surface in the various forms of limestone, is present in minute amounts only, yet enough to supply the substance needed for the shells of shell-fish, corals, etc. Least in amount of the metallic elements mentioned is potassium, which, like sodium, exists mainly in combination with chlorine. Calculating the total amounts of the latter substance, we find that it exceeds in weight any other element present in the salts of sea water, being two sevenths of the whole amount.

Substantially the same result, with variations due to local causes, is obtained when we consider the saline ingredients of lakes having no outlet, and in which, therefore, the leachings of the tributary land area have accumulated for ages. The Great Salt Lake of Utah, the land-locked lakes of the Nevada basin, of California, Oregon, and of the deserts of Asia, Africa, and Australia, all tell the same tale; which may be summarized in the statement that the chlorides of sodium and mag-

nesium, and the sulphates of magnesium and calcium, constitute the bulk of the leachings of the land; while of other substances, potassium alone is present in relatively considerable amount.

While the above analysis shows the ingredients of sea water so far as they can at present be directly determined by chemical analysis, yet the presence of many others is demonstrable, directly or indirectly, from various sources. One is, the mother-waters from the making of sea salt, in which such substances accumulate so as to become ascertainable by chemical means, and even become industrially available in the case of *potash* and *bromine*. Another is the ash of seaweeds, which is indisputably derived from the sea water and contains, among other substances not directly demonstrable in the original water, notable quantities of *iodine* (of which this ash is the commercial source) of *iron*, *manganese*, and *phosphoric acid*. Again, the copper sheathing of vessels, as it is gradually corroded, becomes more or less rich in *silver*, manifestly thrown down from the sea water; and the silver so obtained is associated with minute amounts of *gold*. *Copper*, *lithium*, and *fluorine* have been found in sea water; and it is probable that close search would detect very many of the other chemical elements as ordinary ingredients, in minute amounts. This is what must be expected from the fact that few mineral substances known to us are entirely insoluble even in pure water, and still fewer, in water charged with carbonic acid. The latter is always present in sea water and holds the lime carbonate in solution; on evaporation or boiling, this substance is the first to be precipitated; and thin sheets of limestone from this source are commonly found at the base of rock salt beds, which themselves are evidently the result of the evaporation of segregated bodies of sea water, in the past geological ages.

Summing up the facts concerning the water of the sea and of land-locked lakes with reference to the ingredients of soils needful for the nutrition of plants, it appears that the rock-ingredients leached out in the largest amounts are those of which the smallest quantities only are required by most plants; while of those specially needful for plant nutrition, only potash is removed in practically appreciable amounts by the country drainage.

Insufficient Rainfall.—When, however, the rainfall is, either in total quantity or in its distribution, insufficient to effect this leaching, the substances that otherwise would have passed into the sea are wholly or partially retained in the soil stratum; and when in sufficient amount may become apparent on the surface in the form of efflorescences of "alkali" salts. The presence of the latter is therefore almost always an indication of scanty rainfall, and of other important peculiarities which will be considered more fully hereafter.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE PHYSICAL CHARACTER OF SOILS.

While it is not possible to separate strictly the physical or mechanical from the always more or less concurrent chemical differences caused by climatic influences, some general considerations on the former should precede the discussion of the latter class.

EFFECTS OF ARID AND HUMID CLIMATES ON THE FORMATION OF CLAY.

One of the most important modifications produced by scantiness of rainfall on soil-formation is the great retardation of the formation of clay from feldspathic rocks (kaolinization) and the sediments derived therefrom. An often-quoted example of this influence is that of the quarries of Syene, in Upper Egypt, where most of the great monoliths employed in the construction of the monuments and temples of Egypt were obtained. In this quarry, which has not been worked for at least two thousand years, the rough blocks that were in progress of quarrying when the work was finally abandoned, are said to show an almost perfectly fresh surface to this day; and a well-preserved surface is also shown by the obelisks and pillars made of the same material and transported to Lower Egypt, where, however, the rainfall is somewhat greater. It is a matter of public note that one of these monuments—"Cleopatra's Needle"—for some time set up in Central Park at New York, is in great danger of destruction from the influence of a totally different climate, in which not only the rainfall but the temperature changes are very much greater than in Egypt. Both factors combined will of course prove even more destructive than one alone would be, for a change of temperature that has resulted in the opening of fine cracks at the joints of the mineral components, if followed by a rain and subsequent freeze, may produce a greater effect in a few days than a thousand years of Egyptian climate would have accomplished. In the case of the obelisk at New York the physical effects just mentioned are doubtless the chief factors of destruction; while the chemical process of kaolinization is too slow to be noticeable at once, although it is clear that it will be enormously accelerated by the breaking up of rock caused by the purely physical agencies.

A similar contrast is found in comparing the granitic rocks of the southern Alleghenies with the corresponding rocks in the arid plateau region west of the Rocky Mountains, as well as in California and Arizona. The sharpness of the ridges of the Sierra Madre, and the roughness of the hard granitic surfaces, contrast strikingly with the rounded ranges formed by the "rotten" granites of the Atlantic slope, where sound, unaltered rock can sometimes not be found at a less depth than forty feet. What is true of granite holds correspondingly, of course, in the case of other rocks.

The inference is that a corresponding difference should manifest itself in the soil formed under the influence of these diverse climatic conditions; and even the most cursory observation shows this to be the case. The result may be best expressed in the general statement, that while the soils of the Atlantic slope are prevalently *loams*, containing considerable clay, and even in the case of alluvial lands oftentimes very clayey or heavy: the character of the soils of the arid regions is predominantly *sandy* or *silty*, with but a small proportion of clay; *unless derived*, directly or indirectly, *from preëxisting formations of clay or clay shales*. Of course the character of these "sedentary" clay soils is substantially independent of climate, their substance having been formed in past geological ages.

LIGHT SOILS PREDOMINATE IN ARID CLIMATES.

This incoherence of the soil material in arid climates, resulting from the scarcity of clay,* becomes obvious to the traveler in the sand and dust-storms that sometimes annoy him while traversing *e. g.* what has been conventionally known as the "Great American Desert"—a desert only so long as the life-giving influence of water is withheld from it. Droughts may render the surface of the country in the Atlantic States, or in Europe, as dry as the great plains themselves, yet away from highways or cultivated fields little or no dust will ordinarily be raised by the strongest wind, because of the coherence of the soil, which will generally be found covered by a hard-baked crust. In the arid region, under the same conditions, a mere puff of wind may raise a cloud of dust, and a wind-storm becomes almost unavoidably a sand or dust-storm also. "Dust soils," which during the dry season are even in their natural condition so loose as to rise in clouds and render travel very uncomfortable, are not uncommon in Washington and adjacent parts of Oregon, on the uplands bordering the Columbia and Snake Rivers. The mechanical and chemical analyses of three such soils, given in the table below, will convey some idea of their peculiarities in both respects. The same general facts are known of the other arid regions of the globe, whether in Asia, Africa, or Australia.

Dust Soils of Arid Region.

	17	37	79
	Atahnam Prairie, Yakima Co., Wash.	Rattlesnake Creek, Kittitas Co., Wash.	Plateau on Willow Cr., Morrow Co., Oregon.
Chemical Analysis of Fine Earth.			
Insoluble matter	71.67	78.33	79.21
Soluble silica	5.11 } 76.78	2.20 } 80.53	2.30 } 81.51
Potash (K_2O)	1.07	.70	.89
Soda (Na_2O)	.35	.24	.05
Lime (CaO)	2.00	2.08	1.37
Magnesia (MgO)	1.34	1.47	1.08
Br. ox. of manganese (Mn_3O_4)	.04	.07	.06
Peroxide of iron (Fe_2O_3)	6.88	6.13	5.63
Alumina (Al_2O_3)	7.91	6.12	6.02
Phosphoric acid (P_2O_5)	.13	.18	.18
Sulphuric acid (SO_3)	.02	.02	.03
Water and organic matter	2.82	2.35	2.55
Totals	99.33	99.89	99.37
Humus	4.10	----------	.44
Hygroscopic moisture at 15° C	4.98	3.20	4.92
Mechanical Analysis of Fine Earth.			
Clay	.93	3.59	1.27
Sediment of <.25 mm. hydraulic value	30.93	13.06	32.29
Sediment of .25 to .5 mm.	3.20	5.82	12.75
Sediment of .5 to 2.0 mm.	7.18	27.37	37.51
Sediment of 2.0 to 8.0 mm.	21.88	43.78	10.92
Sediment of 8.0 to 64.0 mm.	32.39	4.57	3.97
Totals	96.57	98.18	98.72

*It must be distinctly understood that what is meant here by "clay" is not the mineral kaolinite, but the gelatinous, plastic, "colloidal" substance that results from its physical disintegration, and which alone plays the part of rendering soils coherent.

Several points of interest that will be discussed in detail further on are illustrated in this table. In their chemical composition the three soils are very good illustrations of generalized soils of the arid region. They also show that the "clay" of physical analysis is not even approximately represented by the "alumina" of the chemical analysis; and that, moreover, the latter substance is not contained in these soils in the form of clay only, since the amount of "soluble silica" is far below that of alumina, while the reverse should be true if they were combined to form clay.

As regards the physical composition, "clay" is shown to be present in very small amounts only; there is a good deal of the finest silt, <0.25 mm.; and then there occurs a conspicuous break in the small amount of sediments just above that point. It may be casually mentioned here that soils of this character are irrigated with difficulty, the water penetrating so slowly that ditches must be run a few feet apart, and the flow continued for a considerable length of time, in order to soak the land.

It will also be noted that the percentages of mineral plant food in these soils are quite large, and that according to all experience they should be found profusely and permanently productive. This forecast is abundantly confirmed by local experience.

"Strong" Soils.—But so generally has the idea of inherent fertility been associated, in the humid regions, with soils of a more or less clayey character, that the terms "strong," "substantial," "durable" are habitually applied to them in contradistinction from "light," "unsubstantial" ones of the sandy or silty type. Hence, the newcomer will frequently be suspicious of the productiveness and durability of soils in the arid region, that experience has proved to be of the highest type in both respects.

The clayey soils that do occur in the arid regions (in California and Spanish America generally known as "adobe"*) owe their existence to one or both of two precedent conditions. Those occupying upland slopes are mostly (though not invariably) directly derived from the disintegration of clay shales that either underlie, or occupy a higher position on the slope; they are therefore either sedentary (soils in place) or colluvial, and derive their clay from that which was formed in former geological ages. The valley adobe lands, on the contrary, are mostly paludal or swamp formations (therefore not formed under "arid" conditions), and represent either the finest materials that remain suspended in slack water, from any source; or sometimes the direct washings of the clayey hill soils, above mentioned. Examples of both kinds are abundant in the Great Valley of California, as well as in the coast ranges of that State.

Great Depth of Soil in Arid Climates.—But it is not only in this point that the physical composition of the soils of arid climates differ from those of humid regions. Another point of great importance is that the difference between soil and subsoil, which is so striking and important in regions of abundant rainfall, is largely obliterated in arid climates. Very commonly hardly a perceptible change of tint or texture is found

* It is to be regretted that in the publications of the U. S. Geological Survey, this name has been erroneously applied to the loam commonly used in the construction of adobe houses. Agriculturally, it means "a heavy clay soil," such as could not be used in building.

for depths of several feet; and what is more important, material from such depths, when thrown on the surface, oftentimes subserves the agricultural uses of a soil nearly or quite as well as the original surface soil. The unconcern with which irrigators proceed to level or otherwise grade their land, even though this may involve covering up large areas of surface soil with subsoil from several feet depth; the rapidity with which the red loam of the placer mines of the Sierra Nevada foothills is re-covered with the natural forest growth of the region, etc., are examples familiar to the residents but surprising to newcomers, who are accustomed to dread the upturning of the subsoil as likely to deprive them of remunerative crops for several years, until the "raw" subsoil has had time to be "vitalized" by the following effect of the atmosphere, and to acquire the needful amount of humus or vegetable mold.*

The cause of this difference is readily understood when we consider what it is that causes the contrast between soil and subsoil in humid climates. As before stated, soils are there, as rule, richer in clay; this clay, becoming partially diffused in the rain-water whenever a somewhat heavy fall occurs, percolates the soil in that condition and tends to accumulate in the subsoil; the result being that almost without exception, the subsoils of the humid regions are very decidedly more clayey than the corresponding surface soils. It is only in alluvial lands formed by periodic overflows, which bring down deposits of varying nature at different times, that any material departure from this rule is found; more rarely it occurs in the case of colluvial soil overlying sandy beds, but supplied with clayey matter from a higher-lying outcrop.

But not only does this clay water tend to render the subsoil more compact and heavy, making it less pervious to water and air, but it is assisted materially in this by the action, discussed below, which tends to leach the lime carbonate out of the surface soil into the subsoil. The accumulated clay is thus frequently more or less cemented into a "hardpan" by lime, partly in the form of carbonate, partly in that of zeolitic (hydrous silicate) compounds; adding to the compactness of the subsoil, and therefore to the usual specific difference between soil and subsoil, viz.: the deficiency or absence of humus, and the difficulty of penetration by, and aëration of, the roots of plants. This point will be further considered below.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE FORMATION OF HUMUS.

Succeeding more or less closely, in time, the physical and chemical agencies upon which depends the formation of soils from rocks and the continued decomposition of the rock powder in soils themselves, there comes another which is most intimately connected with plant growth, and scarcely second in importance to those already referred to. This is the decay of vegetable matter in the soil and the formation of what, in a comprehensive way, is known as humus or vegetable mold—the dark-colored, sometimes jet-black, remnant of vegetable decomposition under at least partial exclusion of air. While now known not to possess that exclusive importance for vegetable nutrition that was at one time

*In the case of a cellar 7 to 10 feet deep, near Nevada City, Cal., the red soil-mass dug out was spread over part of a vegetable garden close by, and as a venture the annual vegetables—tomatoes, beans, watermelons, etc.—were sown just as usual. They not only did well but better than the portions not covered, which had been cultivated for a number of years and were somewhat exhausted thereby.

attributed to it, humus is still recognized as one of the most important soil ingredients for the purposes of practical agriculture; and as its formation is directly dependent upon climatic conditions, its variations in accordance with them form essential points of difference between the soils of humid and arid regions.

Vegetable matter exposed to the action of the *air alone* will in the course of time be completely destroyed by the slow process of combustion ("eremacausis") which is unaccompanied by any essential fermentative action, and is materially assisted by an elevated temperature.

When submerged in water it undergoes a very different process, namely, a gradual conversion into a brown mass, of which the extreme result is peat. The coffee-colored waters of peat-bogs prove that this substance, or a portion of it, is soluble in water; and these brown waters are distinctly acid to test-papers and sometimes even to the taste. Hence the popular designation of soils formed or existing under such conditions as "sour," is strictly correct; and it is well known that the correction of such lands by means of drainage, and the neutralization of the acidity in the soil (usually, in practice, by marling), are conditions-precedent of their profitable cultivation.

Peat-bogs, properly so called, can exist only in cold-temperate, humid climates, not only because the peat moss, which forms their chief vegetation, cannot flourish in dry air, but also because the vegetable matter accumulating under water in warm regions undergoes a more rapid fermentation, whereby much of it is converted into gaseous products (carbonic and marsh gas), and the peaty or humus residue is greatly less in amount. But the conditions for the formation of "sour" soils may be realized in any climate, in the presence of water; as in the "tule" or marsh lands of California as well as of Louisiana and Florida, or in the heads of ravines where springs or oozes of water constantly flow. But in the marshy Arctic lowlands or tundras, the low temperature maintained, even during the short summer, renders the progress of humification extremely slow, preventing the formation of true peat even where the peat moss can maintain its existence.

When, on the contrary, vegetable matter decays *underground* in well-drained land, the process of "humification" has a result different from either of the two preceding cases. The humus formed is of a darker and sometimes jet-black tint, and it imparts no color to water percolating through the soil, being completely insoluble. It is this kind of humus that is desired by the farmer everywhere; it is hailed by him as the mark of high productiveness in the case of new lands, and he considers the maintenance of a proper proportion of it in the cultivated land as essential to profitable culture.

It should be noted right here that the brown humus of bogs is not only neutralized in its acidity by lime, but it is also rendered insoluble in water by its action, and in the course of time is transformed into true, black, insoluble humus.

A product intermediate between peat proper and true soil-humus is found forming the surface of the primeval forests of the coast region of northwestern America, from middle Oregon to Alaska. It is known to the inhabitants as "duff," probably from its resemblance to the holiday pudding of seafaring men, that is usually colored by molasses or brown sugar. The natural "duff" is the result of the decay, above ground, of the

countless trunks of fallen trees that so commonly obstruct the passage of any but the most agile pedestrian in those regions, and upon which the new generation of trees frequently finds a most congenial starting point and foothold. In the course of time, in a climate in which daily rains are the rule rather than the exception, these trunks flatten out and in the aggregate form a surface covering occasionally several feet in thickness, on which rank mosses, Linnæa, various pyrolas, Prince's pine, and similar plants flourish in dense masses; while grasses or anything else affording pasturage are conspicuously absent. The brown tint of the surface layers of the "duff" gradually deepens as the depth increases, and finally there is an insensible transition into normal, black soil.

Influence of Aridity upon the Formation of Humus.

It is easily seen that under the influence of hot, rainless summers, the process first mentioned above, viz., eremacausis or slow combustion, which leaves little residue beyond the mineral ash of the vegetable matter, must prevail very largely; and that, exceptional circumstances apart, the pervious soils of the arid regions are likely to contain less humus than those of humid climates. Broadly speaking, actual examination amply proves this presumption to be correct; and among the agricultural practices which prove very successful in the eastern United States, but largely fail west of the 100th meridian, is one bearing on this very point. Straw, or strawy manure, cannot be profitably plowed in, in its raw condition, in the arid regions, because of its failure to decay and to become a portion of the soil within any reasonable limit of time. Hence, these precious materials were, during the earlier years of California agriculture, most commonly burnt to get them out of the way, so as not to interfere with the success of crops by keeping the soil too open, thus preventing the germination and rooting of the grain. The rapid burning of the straw really did little more than to accomplish in a short time what in the course of nature would have taken two or three years, by the agency of slow eremacausis; ordinarily it was only through the winter months that any material amount of humification could take place, under the influence of moisture and an only moderately low temperature.

Climatic conditions thus compel the farmer of the arid region to "cure" his straw or manure *before* using them on the field; unless, indeed, he can so far control the climate by the command of irrigation water as to restore, substantially, the humid conditions necessary for the rapid fermentation of manure in the soil itself, and for the humification of dry straw or refuse. The extra labor thus involved is a material drawback to free utilization of stable-yard manure, and of all dry vegetable refuse of the farm; and there thus arises a natural inclination toward the use of the easily applicable commercial fertilizers, whenever fertilization becomes necessary. That the openness of most of the soils and the high summer temperature must in a measure modify the selection, and even the mode of application of these, is obvious. To be effective and utilized to the best advantage, they must be put in to a greater depth than would be required where the surface soil is not liable to become air-dry, and perhaps quite hot, during the summer days; for otherwise the roots would be induced, in following the direction of greatest food supply, to come within dangerous proximity to the arid surface.

These considerations apply mainly, of course, to the characteristic soils of the arid climates—the silty and sandy ones—which are the result of a *general* process, and not of the disintegration, in place, of clayey beds or clay shales, or of slow deposition in river or littoral swamps. For in these the atmospheric influences are so far limited by their closeness, as well as by their tenacious retention of moisture, that the process of humification can proceed under much more favorable conditions; and hence we find among this class of soils ("black adobe") very much larger humus percentages, approaching nearly to those of the soils of the Mississippi Valley.

Few of the characteristic upland soils of the arid region contain over 0.40 per cent of true humus;* the mesa (fruit-growing) soils of South California mostly fall below one fourth of 1 per cent (0.25 per cent). In the humid region of the Cotton States, three fourths of 1 per cent is a common amount, and few even of the "pine-woods" soils fall below one half per cent (0.50 per cent). This difference is important because the humus of the soil is the repository of that highly important soil-ingredient, nitrogen, the replacement of which is the most costly of all where clovers cannot be used for green-manuring.

From this statement it might be inferred that the soils of the arid region are, on the whole, deficient in nitrogen, and would soon need its artificial replacement if drawn upon by cultivation. Acting upon this presumption, it has been usual to prescribe the use of nitrogenous fertilizers as one of the first needs of such soils when production began to decrease.

Actual investigation has, however, shown that this presumption is not well grounded. Comparative determinations of the nitrogen contents of the humus (*matiére noire*) of the humid and arid soils, respectively, have shown that in the latter the nitrogen percentage is materially higher than in that of the humid region, in consequence, apparently, of a process of accumulation resulting from the more rapid eremacausis of the nitrogen-free portions of plants. It is reasonably presumable that the humus so rich in nitrogen will lend itself more readily to the process of nitrification which must precede the assimilation of the soil nitrogen; a conclusion corroborated by the well-known abundant occurrence of nitrates in the soils of arid regions. Thus, probably, on the average not only is the aggregate supply of nitrogen in the soils of the arid region approximately equal to that of humid soils, but its absorption by plants is exceptionally favored by the climatic conditions.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE CHEMICAL PROCESSES IN AND CHEMICAL NATURE OF SOILS.

Owing to their intimate interdependence, the chemical processes that are constantly active in soils have to some extent been mentioned already in connection with the discussion of the physical characters. They will now be considered more in detail, in their connection with climatic conditions.

The Leaching Process.—One material difference caused by a copious rainfall as compared with a scanty one, has been mentioned in the

* That is, "matiére noire" as determined according to Grandeau's process of extraction; the only method by which unhumified organic débris can with certainty be excluded from the determination. Both combustion, and extraction with alkaline lye, yield results of no value, varying widely with the season, in one and the same soil.

current leaching-out of the easily-soluble alkali salts, notably those of sodium, and to some extent, of potassium also, together with certain easily-soluble earthy compounds (sulphates and chlorides of calcium and magnesium) and occasionally of other locally abundant soluble substances. These salts being carried through the soil into the country drainage, gradually accumulate in the basins finally receiving the same, whether oceans or inland lakes.

In arid regions these salts are, on the contrary, retained in the soil to a greater or less extent; they tend naturally to accumulate in the lower ground, toward which they are carried by the occasional heavier rainfalls, as well as by the general seepage.

Before considering in detail the effects of this retention of the salts commonly known to be soluble, it is necessary to discuss the effects of climate upon another substance, viz., lime carbonate, commonly presented to us in the form of limestone and chalk.

Lime Carbonate is Soluble.—Although ordinarily considered insoluble in water, when in the form of marble, limestone, or chalk, lime carbonate is yet sufficiently soluble in the soil water—always more or less charged with carbonic acid—to be materially affected by the leaching process. While much less soluble than the salts of potassium, sodium, or magnesium, and also less than gypsum or lime sulphate, yet the constant tendency is *to leach it out of the surface soil into the subsoil*, and *from the soils of the uplands into those of the lowlands*. We shall therefore expect to find, ordinarily, each subsoil a little richer in lime carbonate than its surface soil; and the valley soils more calcareous than those of the adjacent uplands. A comparison of series of such analyses clearly demonstrates the overwhelming prevalence of this difference, so far as the contents of easily soluble lime is concerned; but owing to the fact that the surface soil is more fully exposed to atmospheric influence than the subsoil, the former may at times be found to contain more actual *carbonate* than the subsoil (where it often suffers transformation into other compounds). Such a time is at the end of the dry season, during which (as Storer has first shown) lime carbonate is formed from other compounds of lime; a highly important part of the "fallowing" process. But during the following rainy or winter season the carbonate is again washed into the subsoil, so that in humid climates it may in spring be almost absent from the surface soil itself.

But this being so, it follows that in arid climates, in which the rainfall is insufficient to leach the soil even of its very easily soluble alkali salts, the lime carbonate must of necessity accumulate to even a greater extent than the former. We should therefore expect to find the soils of the region west of the 100th meridian in the United States, and generally those of arid regions everywhere, richer in lime than those of the humid regions, and particularly of those having abundant and frequent rains during a warm summer. For under the latter conditions, the fermentation and oxidation of vegetable matter in the soil is very active, generating a large amount of carbonic acid, which is taken up by the soil water and readily dissolves lime carbonate; and the rainfall being sufficiently copious, this solution is carried through porous soils and subsoils into the country drainage.

Striking exemplifications of this action are sometimes seen in the case of lands either naturally very calcareous or made so by marling, and underdrained by tile. After a number of years not only will the tile

be found incrusted more or less with lime carbonate in the form of "sinter" or tufa, but sometimes, where the flow is habitually somewhat arrested, the accumulation may become so great as to seriously obstruct small tiles, which is therefore inadvisable to use in such soils. The principle involved here is precisely the same as that upon which depends the formation of stalactites in limestone caves, as well as that of the latter themselves.

We shall thus expect to find the upland soils in the regions of summer rains relatively poor in lime, unless indeed they are underlaid more or less directly by, or derived from, some geological formation rich in that substance, from which the supply is kept up. Such is the case in the "residual" soils of the "prairies" of the Mississippi Valley; and generally in limestone regions. And since lime is an exceedingly important soil ingredient, conditioning very materially the thriftiness of soils, it has in the humid regions become a common adage that "a limestone country is a rich country." This is true at least wherever the limestones are not very pure, as is mostly the case in North America; while in the portions of Europe in which chalk—an exceedingly pure limestone—is the country rock, "poor chalk land" is frequently spoken of.

But in the arid regions no such distinction is popularly made. This is natural since, as we have seen, lime carbonate is constantly accumulating in their soils, and therefore it is not to be expected that the connection with a limestone formation should make any material difference in their quality.

This leaching process is of such great importance, both theoretically and practically, as influencing the thriftiness of soils, and therefore the agricultural practice of the humid and arid regions respectively, that a somewhat detailed presentation and discussion of the facts is called for; the more as these have never, as far as I am aware, been definitely observed or placed on record heretofore.

For the study of this question an extended comparison of the composition of the soils of representative arid and humid regions is required; and I have for this purpose gathered together and tabulated for comparison, all the available analyses of soils from the humid and arid portions of the United States, respectively.

COMPARISON OF SOILS FROM THE ARID AND HUMID REGIONS OF THE UNITED STATES.

To give in detail the large number of analyses upon which the following table is based, would exceed the proper limits of this paper. As the greater portion of them are in print in publications not difficult of access, references are given to the records from which the data have been derived; only as regards the soils of Washington and Montana, the data are still in manuscript only, and form part of the records remaining in the writer's hands since the regrettable cessation of the Northern Transcontinental Survey, prosecuted from 1880 to 1883 under the auspices of the Northern Pacific Railroad.

Selection of Data for Comparison—Methods of Analysis.—As it is absolutely essential that in making such comparisons the analyses used should have been made by exactly the same methods, I have included in it exclusively those for which this condition is with certainty fulfilled, namely, the several series made under my own direction, from

1857 to the present time, and those made in connection with the Geological Surveys of Kentucky and Arkansas (first under the direction of Dr. David Dale Owen, and since his death under that of others), mostly by Dr. Robert Peter, the veteran chemist of the Kentucky Survey at this time. Some of which the comparability in this respect is probable but not certain, published in the reports of other States, have been omitted because of this uncertainty.

Soils from Calcareous Areas Omitted.—Another consideration has governed the omission of a large number of soils that have been analyzed on the same plan, from the present comparison. It is plain that if we were to include such as have, in their origin, a more or less direct connection with calcareous formations, either as residuals still underlaid by such formations, or as alluvials and colluvials derived from the same, the climatic influences would be obscured and the comparison still further vitiated by the accident of the numerical proportion between the number of such soils, and those derived from non-calcareous materials, that happened to have been chosen for examination. *Tennessee* forms a case in point: it happens that all of the seventeen soil analyses made for that State during the census work of 1880 are more or less directly connected with calcareous formations which underlie the prominent agricultural subdivisions thus far studied. From this cause Tennessee is unrepresented in the list of States below; and for the same reason a very large proportion of Dr. Peter's analyses of *Kentucky* soils are thrown out, *e. g.* the well-known "blue grass region," and generally that portion of the State covered by limestone formations.

On the same ground, of 141 analyses of *Arkansas* soils by D. D. Owen and Dr. Peter, only 38 could be admitted to comparison. In this case, as in that of Mississippi and Louisiana, the large proportion of "bottom soils" derived directly from the calcareous clays of the Port Hudson beds and from the Loess area, has necessitated the body of the exclusions.

In *Mississippi*, the soils of the cretaceous and tertiary prairies, of the Loess proper, and the heavy soils of the alluvial area (Yazoo bottom) that are directly derived from the Port Hudson clays, are excluded; but not those of the recent alluvium, nor those of the tributaries from the uplands. Thus, out of 130 analyses, 33 have been excluded. The analyses of the brown loams overlying the Loess, though somewhat influenced by the subjacent formation, are nevertheless retained.

Of 25 available analyses of *Louisiana* soils, 7 are excluded because of their direct connection with the Port Hudson and Loess materials.

Of 40 available analyses of *Texas* soils, all but 7 are from "prairie" areas known to be underlaid by calcareous materials. The 7 forming the somewhat doubtful exception (because in part from areas underlaid by calcareous tertiaries) are from points lying both in the humid and arid portions of the State, and therefore would not make a fair showing for either. The same is true of the few analyses of soils from *Indian Territory*.

Of 56 available analyses of *Alabama* soils, all but 6, representing the well-known "prairie" areas, enter into the averages.

All known analyses of *Florida* soils, 7 in number, are included.

Of 60 analyses of *Georgia* soils, 17, representing the essentially calcareous areas of what is known as "Northwest Georgia"—palæozoic

terranes—are excluded from the comparison, together with three others from the tertiary region.

All available soil analyses from *South Carolina* are included. So also are those from *North Carolina*, except those made for the geological survey of the State, the method used in these analyses being unknown, and apparently different from that adopted in the census work of 1880.

The same general system of selection and exclusion has, of course, been put in force on the available soil analyses from the arid regions; represented, thus far, by *California*, *Washington*, and central *Montana*. As is well known to geologists, these are regions very deficient in limestone formations, so that it is difficult to obtain material for a home supply of lime for building and other purposes. It is true that the rock material of the cretaceous and tertiary beds covering large portions of these regions are often more or less calcareous, and would, by disintegration, yield a slightly calcareous average material. But the same is true of a large portion of the humid region on areas which nevertheless have not been ruled out from this comparison. Wherever it is known that a specially calcareous deposit is near at hand, and may have contributed an extra proportion of calcic carbonate, the analysis has been ruled out; and on the same ground as in the case of the soils of the Lower Mississippi, where the old swamp (Port Hudson) beds have been an essential contributory factor, the corresponding soils from the troughs of the valley of California have been excluded. Thus of a total of 236 analyses of *California* soils, 38 have been excluded from the averages.

Out of 80 analyses of *Washington* soils, 4 showing unusual proportions of lime were ruled out on suspicion that there might be a special source of lime involved. In the rest, the range is so steadily from a little below one to a little over two per cent, that there was no basis for a discrimination, the more as the country is destitute of limestones, and save, at a few points, even of any obviously marly formations.

In the case of *Montana*, 14 out of 43 soils have been ruled out, mostly on suspicion of, but partly because of known connection with limestone formations; as *e. g.* in the case of lands at the foot of the Big Snowies, a limestone range forming part of the northern rim of the Judith Basin.

The rule thus having been applied, as impartially as possible, to the soils of both humid and arid regions, I believe that the conclusions flowing from a discussion of the results of the comparison is entitled to as much weight as are those of any comparison based on large numbers of observations made, not with reference to the special point under consideration, but with a practical object of which the governing conditions were more or less uncertain and required to be ascertained by a process of elimination.

The table gives, first, the averages for each ingredient for each of the States represented; the number of analyses from which the averages are derived being given in each case. These averages are given separately for the States of the humid and arid regions, respectively; and at the base of each group the grand average is shown in two forms. The first gives the figures as derived from *the aggregate number of soil analyses in each great group*, being 466 for the humid and 313 for the arid, divided into the totals resulting from the summation of each ingredient for the whole 466.

The second form is that in which *the soils of each State are considered as representative* of the general character of such State, as the result of

intentional selection; such as actually occurred in the cases of those included in the census work of 1880. The figures given here are therefore the result of a *summation of the State averages* as such, and of their division by the number of States represented.

It may be cursorily noted here that while these two modes of presentation do change the figures a little, yet in either form the same general result is outlined with striking accuracy. It will be noted that in some cases the averages for States are not all based upon the same number of analyses. This happens mostly because of omissions made in determinations, occurring most frequently in the case of the item "soluble silica." It must be understood that in the earlier work the importance of ascertaining this point in every case had not been thought of. Hence it is entirely wanting in the analyses representing Kentucky and Arkansas, and in all the earlier work relating to Mississippi. This explains why in some cases the averages of the first two columns ("insoluble residue" and "soluble silica") do not sum up correctly in the third column, which, where both determinations have been made, should be the sum of the preceding.

To amplify the evidence as much as possible there are also given six analyses from *Colorado*, *New Mexico*, and *Utah*, made for the purpose of ascertaining the probable success of sugar beets, and therefore, as it happens, representing characteristic "mesa" or plateau lands. These analyses were made in the laboratory of the California Experiment Station by Mr. H. P. Dyer, chemist to the Utah Beet Sugary, near Lehi.

The nine analyses from *Wyoming*, made at the Experiment Station at Laramie, while perhaps not strictly comparable because of a somewhat different method of preparing the soil-solution (Kedzie's), are evidently in line with the rest from the arid region.

References to Sources of Data.

For the analyses of soils from the States of North and South Carolina, Georgia, Florida, and Alabama, Report of U. S. Census for 1880, vol. 6.

For the States of Mississippi, Louisiana, and Arkansas, *ibid.*, vol. 5; from the reports of the respective geological surveys and reconnoissances, and partly from manuscript records still unpublished.

For Kentucky, the reports of the Geological Survey of Kentucky from 185- to the present time; analyses by Dr. Robert Peter.

For California, the several reports of the College of Agriculture and Experiment Station of the University of California, from 1877 to the present time.

For Washington and Montana, the manuscript records of the Northern Transcontinental Survey, from 1880 to 1883.

For Utah, New Mexico, and Colorado, manuscript record of work by H. P. Dyer, Chemist to the Utah Sugar Company, Lehi, U. T.

For Wyoming, Bulletin No. 6 of the Wyoming Experiment Station, May, 1892.

The data concerning humus are derived from investigations made at the California Station. See "Agricultural Science," April, 1894.

Average Composition of Soils in the Humid and Arid Regions of the United States.

Name of State.	No. of Soils Averaged	Insoluble Residue	Soluble Silica	Total Insoluble Residue and Soluble Silica	Potash	Soda	Lime	Magnesia	Brown Oxid Manganese	Peroxid of Iron	Alumina	Phosphoric Acid	Sulphuric Acid	Water and Organic Matter	Total	Hygroscopic Moisture	Temperature of Absorption, C.	Soluble Phosphoric Acid	Carbonic Acid	Humus Per Cent in Soil†	Nitrogen Per Cent in Humus†	Nitrogen Per Cent in Soil†
North Carolina	20	81.627	3.505	85.133	.145	.057	.088	.080	.071	4.718	5.713	.118	.061	3.977	100.163	4.282	21.1	....	.....	1.50	5.2	.132
South Carolina	11	83.493	3.425	86.919	.123	.059	.114	.154	.083	2.771	5.709	.097	.108	3.899	100.039	4.228	23.6	....	.....			
Georgia	40	86.066	2.887	88.954	.150	.065	.076	.099	.090	2.751	4.018	.111	.096	3.619	100.029	3.541	17.0	....	.....			
Florida	7	94.277	1.172	95.449	.101	.034	.091	.027	.077	.749	1.169	.091	.069	2.274	100.136	2.204	24.4	....	.....			
Alabama	50	81.576	4.893	86.469	.231	.073	.169	.210	.120	3.814	2.699	.134	.053	4.039	100.611	7.066	20.2	....	.....			
Mississippi	97	85.870	4.391	89.714	.276	.109	.145	.312	.137	2.643	4.069	.091	.029	3.331	100.176	5.410	15.4	....	.....			
Arkansas	38	.....	.....	88.539	.165	.056	.081	.430	.205	3.099	3.511	.150	.045	3.704	99.931	2.473	.....	.....	.....			
Kentucky	185	.....	.....	86.719	.199	.104	.081	.193	.197	6.008	3.523	.109	.038	3.691	100.862	1.845	.....	.....	.....			
Louisiana	18	78.393	6.837	85.231	.290	.086	.163	.379	.153	4.543	5.667	.129	.087	3.480	100.261	6.656	24.5	....	.....			
Total for humid region	466	84.031	4.212	87.687	.216	.091	.108	.225	.133	3.131	4.296	.113	.052	3.644	100.178	4.650	18.5	....	.....	.....	.....	.....
Averages by States	.....	84.472	3.873	88.126	.187	.071	.112	.209	.126	3.455	4.008	.114	.065	3.557	100.093	4.189	20.9	....	.....	.....	.....	.....
California	198	67.882	8.960	76.842	.644	.277	1.075	1.488	.062	6.303	8.721	.083	.048	4.396	100.048	5.925	.....	.03	1.148	.75	15.87	.101
Washington	76	75.021	3.673	78.696	.777	.249	1.378	1.171	.049	5.530	6.063	.173	.028	5.226	99.952	5.941	.....	.....	.403	.....	.....	.....
Montana	39	66.141	6.235	72.376	1.005	.226	2.483	1.494	.057	4.459	7.145	.178	.029	7.133	99.935	8.712	.....	.....	2.398	.....	.....	.....
Total for arid region	313	70.565	7.266	76.135	.729	.264	1.362	1.411	.059	5.752	7.888	.117	.041	4.945	99.993	6.281	.....	.....	1.316	.....	.....	.....
Averages by States	.....	69.681	6.289	75.652	.825	.251	1.645	1.384	.056	5.431	7.309	.144	.035	5.585	99.978	6.859	.....	.....	1.316	.....	.....	.....
Utah	4	74.40	7.50	81.90	.840	.320	1.590	.960	.030	6.410	3.150	.192	.031	4.140	99.563	.....	.....	.....	.....	.....	.....	.....
New Mexico	1	63.20	7.32	70.52	.732	.176	*10.060	1.007	.020	4.031	2.560	.103	.082	3.197	99.849	CO_2 7.360	.....	.....	.....	.....	.....	.....
Colorado	1	69.61	11.12	80.73	.964	.113	.706	.845	.006	6.640	5.560	.090	.033	4.430	100.117	.....	.....	.....	.....	.....	.....	.....
Average of the six	.....	68.74	8.65	77.72	.845	.203	.882	.937	.010	5.670	3.757	.128	.049	3.922	99.843	.....	.....	.....	.....	.....	.....	.....
Wyoming	9	75.79	2.45	78.24	.720	.470	2.670	1.450	.....	3.320	5.850	.180	.100	4.790	99.690	.....	.....	.....	1.90	.....	.....	.....

*Omitted in the average. †Approximate averages from limited data.

LIME CONTENTS OF SOILS IN THE ARID AND HUMID REGIONS.

Considering in this table, first, the ingredient under discussion above, viz.: *lime*, a glance at the column for the two regions shows a surprising and evidently intrinsic and material difference; approximating, in the average by totals, to the proportion of 1 to 12; in the average by States, 1 to 14¼. This difference is so great that no accidental errors in the selection or analysis of the soils can, to any material degree, weaken the overwhelming proof of the correctness of the inference drawn upon theoretical grounds, that the soils of the arid regions must be richer in lime than those of the humid countries. For the differences in derivation would, in view of the prevalence of limestone formations in the humid regions concerned, produce exactly the reverse condition of things from that which is actually found to exist; and if further proof were needed, it can readily be found in the detailed discussion of the analyses of the soils of the arid areas forming the contrast. This shows that, for instance, in Washington highly calcareous soils are directly derived from the black basaltic rocks; while similarly calcareous lands are found, in California, to be the outcome of the decomposition of granites, diorites, and lavas.

It is not easy to overrate the importance of this feature of the soils of the arid region, as it is intimately connected with other theoretically and practically important facts which will be discussed later.

Now if it be true that "a limestone country is a rich country" in the humid regions, and if, as the tables show, the soils of the arid regions are *all* calcareous to the extent to which that property serves its general purpose,* then it must also be true that when the deficiency of rainfall in the arid regions is supplied by irrigation, the soils of the arid regions should be exceptionally productive as compared with those of the regions of summer rains.

I think experience shows that this is strictly true, and that in the arid region "poor" soils are very much less common than in the humid climates. As farmers would express it, the land is "*all marled*" in its natural condition; and a smaller area can there, on the average, be made to sustain a family.

Is there not here a clew to the fact that has excited the surprise of many, viz.: that arid or irrigation countries have in the past times been the chosen abodes of dense populations, whether about the rock-hewn cities of Syria, or in those of Arizona? Is it not true that the desert is a desert merely in appearance, and that the life-giving water, brought by the hand of man, is all that is needed to convert it into a land where milk and honey flows?

Upland and Lowland Vegetation in the Arid and Humid Regions.

In the *humid regions* there is always a marked difference between the vegetation of uplands and lowlands, arising not merely from the difference in moisture supply, but evidently of a specific nature. When we

*The lime-percentage usually mentioned in text-books as necessary to the "calcareous" character of a soil ("vigorous effervescence with acids"), implying not less than 4 per cent of the carbonate, is very much greater than is actually necessary to impart all the desirable and characteristic agricultural and vegetative features to soils that depend upon the action of lime. Very much less is, moreover, required for that purpose in sandy soils than in those which contain much clay. (See Report of Tenth Census, Vol. 5, page 64.) The important point is that an excess of lime carbonate must always be present, over and above the lime occurring in combination with other acids.

discuss the characteristic plants in detail, it becomes obvious that it is *lime* vegetation that forms the characteristic difference in most cases; and by way of counter-proof we find that when the uplands are *themselves* of a calcareous nature, a part of the valley flora ascends into them. To mention one of many instances: The tulip tree (liriodendron, whitewood) is a lowland tree over the greater part of its area of occurrence; but in the Loess or Cane Hills area of the Southwest, as well as in the cretaceous (limestone) hill country of Mississippi, it is conspicuous in the uplands. The same is true of the black walnut, the linden, and many other trees and shrubs characteristic of limy soils.

In the *arid region*, on the contrary, the main difference observable in upland and lowland vegetation (outside of mountain influences) is entirely referrible to moisture conditions; the proof being that so soon as the uplands are irrigated the lowland flora, so far as it is distinct, takes possession. This uniformity of upland and lowland vegetation is particularly conspicuous in the comparatively restricted floras of the Pacific Northwest—Eastern Oregon and Washington, and Montana; where one may travel for days over hill and dale and plains, all equally arid, with scarcely a change in the character of the flora, especially during the dry season. Both uplands and lowlands being nearly equally calcareous, there is no reason for any material difference.

Formation of Calcareous Hardpan in Subsoils.

As stated above, subsoils are in all ordinary cases richer in lime compounds than the overlying surface soil, owing to the solubility of lime carbonate in the soil water, which being followed by air when rain ceases, gradually deposits the lime in the lower layers of the arable stratum, by the well-understood process of aëration. In humid climates, however, the frequent rains, so very variable in amount, rarely allow of the accumulation of very large amounts of this substance at a particular depth. Hence, while in such regions (the prairies of Mississippi and Louisiana) we often find, in soils overlying calcareous strata, a formation of whitish concretions (commonly known as "white gravel") of lime carbonate, yet the formation of continuous layers or sheets of subsoil cemented by lime is not frequent.

In arid regions, on the contrary, the limited rainfall usually penetrates only to a relatively slight depth—a few feet—whence the water afterwards reascends to be dissipated by evaporation. Thus the lime carbonate dissolved in its descent gradually accumulates within a very limited thickness of soil, and chiefly at the lowest point usually reached by it. Concurrently, the diffused clay brought down by each rain stops at or near the same level; and both substances combine to form a mechanical union into a subsoil layer of "hardpan," the cement of which is lime carbonate, and which therefore effervesces ("sizzes") to a greater or less degree when touched with a drop of acid.

These hardpan sheets are usually more or less discontinuous, the areas occupied by them being commonly of a rounded or oblong shape, and lowest in the middle. In case of unusually copious rains, or when irrigated, they may frequently be recognized by the formation of temporary ponds, deepest in the middle or axis of the sheet. Such stagnation of water serves ultimately, of course, to increase the hardness and thickness of the hardpan sheet, by the further dissolution of lime during

the fermentation of vegetable matter that always occurs in stagnant water, and its subsequent deposition upon the concrete already formed.

Such hardpan areas are familiar to cultivators in the arid regions throughout the world; from the Rocky Mountains to the Pacific Coast, as well as in northwest India, where the "kankar" is a formidable obstacle to the cultivation of lands otherwise very rich and capable of profuse production. It there seems to assume, more frequently than in California and Arizona, the form of a hard crystalline, though very impure limestone, which no tool short of a crowbar can deal with. Of course roots cannot penetrate it, and after irrigation the water stands on the lands underlaid by it, drowning out what might otherwise have been a fair crop. The trouble is experienced to some extent in California, in some portions of the Great Valley, where soils of a fine silty character prevail; less often in the more coarsely sandy lands. In the heavy clay lands ("adobe") of the lower grounds, such accumulations of lime carbonate are also quite common, as might be expected; but, contrary to expectation, they are usually less hard and offer less obstruction to roots and to the penetration of water than is the case in the silt soils. Moreover, the lime hardpan in these clay soils crumbles very rapidly upon exposure to air, or thorough drainage, and is therefore less injurious and less difficult to deal with than in other soils.

MAGNESIA CONTENTS OF SOILS IN THE ARID AND HUMID REGIONS.

While the differences in respect to the proportions of lime are the most prominent and decided, yet the related substance—magnesia—shows also a very marked and constant difference as between the soils of the humid and arid regions. It will be observed that the general average for magnesia in the soils of the Atlantic slope is about double that of lime; Florida being the only State in which the average (of seven analyses) is lower for magnesia than for lime. In the arid region, on the contrary, magnesia on the general average is nearly the same as lime; in the average by States, slightly above it; thus bringing the ratio for the two regions for magnesia up from one to six or seven. This also is so decisive a showing that no accident could bring it about; we must conclude that climatic influences have dealt with magnesia similarly as with lime; which from the standpoint of the chemist is just what might be expected, since magnesia carbonate behaves very much like that of lime toward carbonated waters. It is not, however, known to exert any peculiar influence upon soils or plant nutrition; and hence, while its presence in the soils of the arid region is corroborative of the evidence concerning lime, it is not of similar practical significance.

INFLUENCE OF CLIMATIC CONDITIONS UPON THE "INSOLUBLE RESIDUE."

Remembering, in discussing the facts shown by the table, that the fundamental difference between the *régime* of the humid and arid regions is the presence or absence of an almost continuous leaching process, in which the carbonated water of the soil is the solvent; remembering also that the least soluble portion of rocks and soils is quartz or silica (sand, as usually understood), it would be predicable that this ingredient should in the humid region be found to be more abundant in soils than in the arid. This portion is represented by the "insoluble residue" of the table.

Inspection shows that both in the averages of the single States, and in both of the general averages, this difference between the soils of the humid and arid regions of the United States is strongly pronounced; the ratio being substantially as 70 per cent in the arid region to 84 per cent in the humid.

We must then conclude that the leaching process must have influenced materially other soil ingredients than lime, which have remained behind in such amounts as to depress the percentage of insoluble residue in the soils. It remains to be shown what are the substances so retained.

"*Soluble Silica*" *and Alumina*.—The ingredient most nearly correlated with the "insoluble residue" is the silica which remains behind with it when the acid with which the soil has been treated preparatory to analysis is evaporated to dryness. The gelatinous or pulverulent silica set free by the acid from the soil silicates being thus rendered insoluble in acid and water, it is separated from the *really* insoluble and undecomposed minerals by boiling with a strong solution of sodic carbonate, to which, after boiling, a few drops of strong caustic soda lye has been added in order to prevent the re-precipitation of part of the soluble silica. The amount of the latter is obviously the measure of the extent to which the soil silicates have been decomposed in the treatment with acid.

The most prominent of these is usually supposed to be clay—the hydrous silicate of alumina, that in its purest condition forms kaolinite or porcelain earth. Any alumina found in the usual course of soil analysis is generally referred to this mineral, which contains silica and alumina nearly in the proportion of 46 to 40.

In very many cases, however, the reference of these two ingredients to "clay" is manifestly unjustified. This is clearly so when (as not infrequently happens) the amount of alumina found exceeds that which could form clay with the ascertained percentage of soluble silica; it is almost as certainly so when, in addition to the alumina, other bases (notably potash, lime, and magnesia) are found in proportions which preclude their being in combination with any other acidic compounds present. The only possible inference in such cases is that these bases, together with at least a portion of the alumina, are present in the form of hydrous, and therefore easily decomposable, silicates, or zeolites.

The subjoined analysis of a "clay" obtained in the usual process of mechanical soil analysis (by precipitating with common salt the turbid water remaining after twenty-four hours' subsidence in a column of 200 millimeters), from a very generalized soil of northern Mississippi, shows one of the many cases in which the numerical ratios of the several ingredients are incompatible with the assumption that silica and alumina are present in combination as clay (kaolinite) only:

Insoluble matter	15.96
Soluble silica	33.10
Potash (K_2O)	1.47
Soda (Na_2O)	1.70
Lime (CaO)	.09
Magnesia (MgO)	1.33
Br. ox. of manganese (Mn_3O_4)	.30
Peroxid of iron (Fe_2O_3)	18.76
Alumina (Al_2O_3)	18.19
Phosphoric acid (P_2O_5)	.18
Sulphuric acid (SO_3)	.06
Carbonic acid (CO_2)	None.
Water and organic matter	9.00
Total	100.14

If in this case we assign all the alumina to silica, as required for the composition of kaolinite or true clay, there remains a trifle over twelve (12.17) per cent of silica to be allotted to the other bases present. Deducting from this the ascertained amount of silica soluble in sodic carbonate, preëxisting in the raw material (0.38 per cent), we come to 11.79 per cent as the amount of silica which must have been in combinations other than kaolinite; viz., hydrous silicates or soil zeolites, formed either with the bases other than alumina shown in the analysis, or more probable, perhaps, containing some of the alumina itself in essential combination.

We are thus enabled to obtain, from the determination of the "soluble silica," an estimate of the extent to which these soil zeolites, that form so important a portion of the soil in being the repositories of the "reserve" of more or less available mineral plant food, are present in the soils of the several regions. A glance at the table shows that the general average of soluble silica is very much greater in the soils of the arid regions than in those of the humid; approximating one to two in favor of the arid division.

But, looking at the details of the several States, however, we find that on the arid side Washington has a relatively low figure for soluble silica; that in the average, however, is overborne by the high figures for California and Montana. The explanation of this fact probably lies in the derivation of the majority of the Washington soils examined, from lake deposits brought down gradually from the humid region at the heads of the Columbia drainage, where sandy beds are very prevalent; while the country rock—the basaltic eruptives—are very basic, and moreover, slow to disintegrate. In California and Montana the rocks are indefinitely varied, and the general outcome of their weathering is plainly a predominance of complex hydrous silicates in the soils, as compared with humid regions.

Zeolites are Repositories of Plant Food.

Nor should this be a matter of surprise when we consider the agencies which are brought to bear upon the soils of the arid regions with so much greater intensity than can be the case where the solutions resulting from the weathering process are continually removed as fast as formed, by the continuous leaching effect of atmospheric waters. In the soils of regions where summer rains are insignificant or wanting, these solutions not only remain, but are concentrated by evaporation to a point that, in the nature of the case, can never be reached in humid climates. Prominent among these soluble ingredients are the silicates and carbonates of the two alkalies, potash and soda. The former, when filtered through a soil containing the carbonates of lime and magnesia, will soon be transformed into complex silicates, in which potash takes precedence of soda, and which, existing in a very finely divided (at the outset in a gelatinous) condition, serve as an ever-ready reservoir to catch and store the lingering alkalies as they are set free from the rocks, whether in the form of soluble silicates or carbonates. The latter have still another important effect: in the concentrated form at least, they themselves are effective in decomposing silicate minerals refractory to milder agencies, such as calcic carbonate solutions; and thus the more decomposed state in which we find the soil minerals of the arid regions is intelligible on that ground alone.

But it must not be forgotten that lime carbonate, though less effective than the corresponding alkali solutions, nevertheless is known to produce, by long continued action, chemical effects similar to those that are more quickly and energetically brought about by the action of caustic lime. In fact, the agricultural effects of "liming" are only *in degree* different from those produced by "marling" with finely pulverized carbonate; and in nature the same relation is strikingly exemplified in the peculiarly black humus that is characteristic of calcareous soils, but which can be much more quickly formed under the influence of caustic lime on peaty soils. In the analysis of silicates we employ caustic lime for the setting-free of the alkalies, and the formation of easily decomposable silicates, by igniting the mixture; but the carbonate will slowly produce a similar change, both in the laboratory and in the soils in which it is constantly present. This is strikingly seen when we contrast the analyses of calcareous clay soils of the humid regions with the corresponding non-calcareous ones of the same. In the former the proportions of dissolved silica and alumina are almost invariably much greater than in the latter, so far as such comparisons are practicable without assured absolute identity of materials. That is, calcareous clays or clay soils are so sure to yield to the analyst large precipitates of alumina, that experience teaches him to employ smaller amounts for analysis than he would of non-calcareous materials, in order to avoid unmanageably large bulks of aluminic hydrate. It is but rarely that even the heaviest non-calcareous soils yield to the acid usually used in soil analysis more than 10 per cent of alumina; while heavy calcareous clay ("prairie") soils commonly yield between 13 and 20 per cent.* It would be interesting to verify this relation by artificial digestions of one and the same clays with calcic carbonate at high temperature, as it must always be extremely difficult to insure absolute identity of all other conditions in the natural materials.

In most of these cases, what is true of alumina is also true of the soluble silica. But since the latter is constantly liable to be dissolved out by solutions of carbonated alkalies, it is not surprising that this relation is not always shown. What *is* shown in very many cases is that, since the amount of alumina dissolved greatly exceeds that of soluble silica, a portion of the latter must be present in a different form from that of clay (kaolinite); the only choice being between that of complex hydrous silicates (none of which, however, could contain as large a percentage of alumina as clay itself) and *aluminic hydrate*. The latter is alone capable of explaining the presence of more alumina than silica in easily soluble form; and the visible occurrence of "gibbsite" in modern formations renders this a perfectly simple and acceptable explanation. Since this mineral is known to be incapable of crystallization, we are moreover led to the presumption that it will as a rule be found in the finest portions of the soil, viz., in the "clay" of mechanical analysis. What part it may take in modifying the physical properties of the soil, we can thus far only conjecture; in two conspicuous cases of this kind, from Mississippi and California,† the soil material is charac-

* Report of the Tenth Census, vols. 5 and 6; see especially the analyses of soils from Mississippi and Alabama. Also the Reports of the California Experiment Station.

† These cases are Nos. 203 and 207, Mississippi (Rept. 10th Census, vol. 5, p. 256), in which the soluble silica and alumina stand in the ratio of about seven to over twenty; and No. 703, California (*ibid.*, vol. 6, page 712), in which the ratio is as nine to nearly sixteen. See also the table above, page 119.

terized by such extraordinary tenacity and adhesiveness as to render tillage almost practically impossible, while the natural plant growth is very scanty. No corresponding extreme physical condition is, however, exhibited by the soils from Washington and Oregon, of which analyses are given on page 108, in which an excess of alumina over soluble silica is likewise shown.

There is no very obvious reason, from the chemical standpoint, why *iron*—that is, ferric hydrate or iron rust—should be more abundant in the soils of the arid regions, as the averages given in the table suggest; moreover, the fact does not impress itself upon the eye, since the whitish or grayish tints are by far more common in the arid than in the humid regions of the United States, at least. The California average is considerably influenced by the very highly ferruginous soils from the foothills of the Sierra Nevada; that of Oregon by the black, highly ferruginous country rock from which they are partly derived. The average for Montana is not higher than that of three States of the humid region, and less than that of Kentucky. We might imagine a cause for depletion of the soils of the humid areas of iron, in the frequency with which humid moisture and high temperature will, during the summer, concur toward the bringing about of a reducing process in the soil, which by bringing the iron into proto-carbonate solution would make it liable to be leached into the subsoil, as is frequently the case; yet the resulting "black gravel" or bog ore, in its various forms, is of not infrequent occurrence in the arid regions also. I therefore am not satisfied that a constant difference due to climatic conditions is shown by the data thus far at command.

An unexpected and apparently well-defined contrary relation appears to be shown as regards the related metal, *manganese;* the average percentage of which is in all cases less in the arid than in the humid region, on the average over one to two. The cause of this relation is altogether obscure; it is too well maintained to be accidental; in any case it is, so far as we know, of no consequence to vegetation.

As regards that highly important soil ingredient, *phosphoric acid*, the indication in the table that there is no characteristic difference in the average contents in soils of the arid and humid regions, respectively, is doubtless correct. This substance is so tenaciously retained by *all* soils that there is no conceivable reason why there should be any material influence exerted upon its quantity by leaching, or by any of the differences in the process of weathering that are known to exist between the two climatic regions. Moreover, it is obvious that the average for the arid region is made up out of very widely divergent data; that of California being exceptionally low (lower than any of those for the humid region), while those for Washington and Montana are exceptionally high. The latter is due to country rocks showing abundance of microscopic crystals of apatite, which in some cases raise the contents of soils in phosphoric acid to nearly twice the average given for the States.

The forecast that for most California soils, fertilization with phosphates is of exceptional importance, has already been abundantly confirmed by experience.

The showing made by the table regarding *sulphuric acid*, that sulphates are less abundant in the soils of the arid than of the humid region, is surprising in view of the prevalence of sulphates of the alkalies, which show themselves in the form of efflorescence but too frequently.

It is true that the majority of such "alkali soils" has, on account of their exceptional and local nature (and usually, heavy lime-contents), been excluded from the comparison; otherwise the showing would have been quite the reverse. No significance attaches, therefore, to these figures.

POTASH AND SODA IN THE SOILS OF THE ARID AND HUMID REGIONS.

The compounds of alkali metals, potassium and sodium, being on the whole much more soluble in water, even without the concurrence of carbonic acid, than those of calcium and magnesium, the leaching process which creates such pronounced differences in the case of the two earths must affect the alkali compounds very materially. Comparison of the soils of the two regions in this respect shows, indeed, very great differences in the average contents of potash and soda. For potash the ratio is 0.216 to 0.725 per cent on the general average, and 0.187 to 0.825 per cent in the average by States; for soda, 0.091 to 0.264 per cent on the general average, and 0.071 to 0.251 per cent in the average by States. For both, therefore, the general average ratio is as 1 to between 3 and 4, for the humid as against the arid region.

It is curious that an approximation to the ratio of 1 to 3, or somewhat less, is maintained in the average proportion of soda to potash in both regions; but this does not by any means hold good in detail, very high potash percentages being often accompanied by figures for soda very much below the above ratio. This is the result of an important difference in the chemical behavior of the two alkalies, which must be considered somewhat in detail in order to obtain a clear conception of the process by which "alkali soils" are formed.

The process of "kaolinization" being that by which clays are formed out of feldspathic minerals and rocks such as granite, syenite, trachyte, etc., results in the simultaneous formation of solutions of carbonates and silicates of potash and soda. These coming in contact with the corresponding compounds of lime and magnesia, also common products of rock decomposition, are partly taken up by the latter, forming complex insoluble, hydrous silicates (zeolites). In these, however, potash whenever present takes precedence of soda; so that when a solution of a potash compound is brought in contact with a zeolite containing much soda, the latter is partially or wholly displaced and, being soluble, tends to be washed away by the rainfall into the country drainage. Hence, potash, fortunately for agriculture, is tenaciously held by soils, while soda accumulates only where the rainfall or drainage is insufficient to effect proper leaching, and in that case manifests itself in the formation of what is popularly known as "alkali soils"; namely, those in which a notable amount of soluble salts exists, and is kept in circulation by the alternation of rainfall and evaporation; the latter causing the salts to accumulate at the surface and to manifest themselves in the form of saline crusts or efflorescences.

The designation of "alkali" soil is, however, popularly bestowed somewhat indiscriminately upon two classes of lands, of very different origin, and requiring for their reclamation quite different treatment. In both cases it is mainly the salts of the alkalies—potash and soda—that imbue the soil and tend to injure vegetation. But when we have to deal with *seashore* lands that owe their saline contents only to the

more or less continuous flooding with salt or brackish water, the conditions differ materially from those prevailing in the case of the *true* alkali soils, which owe their contents of salts to the scantiness of the rainfall, as heretofore explained.

In the former case, that of *saline* lands, it is chiefly common salt (chlorid of sodium) with some bittern (chlorids and sulphates of calcium and magnesium) that forms the soluble impregnation; which is, of course, practically independent of climatic conditions. In the latter, while common salt is also commonly present, the most abundant is usually Glauber's salt (sulphate of soda), and with it very frequently, as the least welcome ingredient, carbonate of soda (sal soda). According to chemical laws, the presence of the latter substance excludes, practically, the earthy salts classed above as bittern.

The saline shore lands, being practically independent of climatic influences, lie outside of the limits of this paper.

Alkali lands proper are a characteristic feature of *all* regions of scanty rainfall, and are found on all the continents, including Europe, which has predominantly a humid climate. Occasionally we find in the humid regions limited areas to which salts of various kinds are currently supplied from adjacent saline formations, as may be seen at some points in southern Mississippi and northern Louisiana. But such phenomena are entirely local, and do not extend far from the source of supply, because the soluble salts are soon washed into the country drainage by the abundant rains.

In the arid regions, on the contrary, the substances composing the alkali salts are not only retained in their first soluble form, but by their continued presence influence profoundly the processes of soil-formation in several ways.

In the accumulation of alkali salts much of course depends upon the nature of the soil; for it is obvious that in very porous soils the leaching-out can occur much more readily than in those that permit of but very slow percolation, so that a rain may chiefly run off from the surface, and cease before even an approach to a complete downward penetration can have occurred. It is therefore a well-known fact that alkali is most troublesome in the heavier (adobe) lands; and as these are apt, in addition, to coincide with the lower ground, toward which the soluble salts are naturally carried with the seepage, it is not uncommonly found impracticable to cultivate these extremely rich lands without special methods tending either to diminish the alkali itself, or at least to prevent its accumulation at the surface, where its most injurious effects are produced.

It need hardly be said that, special qualities of soil apart, the alkali salts decrease as hills or mountains are approached, where increased slope, and usually pervious soils, combine to permit of their leaching-out with even a relatively scanty rainfall. And inasmuch as ordinarily the rainfall increases rapidly with elevation, everything concurs to prevent the accumulation of alkali in mountainous, or even hilly regions. High-lying plains or plateaus, however, do not by any means necessarily share this exemption; as is well illustrated in the case of the great interior plateaus of America and Asia.

Humus.—The figures of the last three columns of the table give the data thus far available in the comparison of the humus-contents of the soils of the arid and humid regions, respectively, together with the nitro-

gen percentages contained in the humus substance as stated on page 112. The available data being limited, these figures have to be taken with considerable allowance, especially as regards the average humus-contents of the two classes of soils for which only a very few determinations are available. The figures given for the nitrogen contents, however, may be considered fairly representative and accurate. While it thus appears that, as in the case of potash, the nitrogen percentage in the humus of the two regions approximate to the ratio of 1 to 3, it should be stated that in numerous cases this ratio rises to 1 to 6 and even 1 to 7; the nitrogen percentage in the arid humus reaching as high as 18.66 per cent in one case, thus materially exceeding the nitrogen contents of the albuminoid group, or flesh-forming substances. This is, perhaps, next to the case of lime, the most striking contrast in one of the essential factors of soil fertility in the two regions, and cannot fail to exert a striking influence upon the behavior and consequent treatment of such soil under cultivation. The various bearings and precise character of this influence require much additional study.

THE ALKALI LANDS OF THE ARID REGIONS.

CLIMATIC LIMITATIONS OF ALKALI LANDS.

California.—The question concerning the amount of rainfall under which alkali salts can be retained by the soil to a noticeable and injurious extent can best, perhaps, be investigated in California, where the eastern portion of the great valley constitutes a region of very regularly varied rainfall; ranging from an annual mean of 34.60 inches at Redding on the north, to (usually) less than 6 inches at Bakersfield on the south. The following table shows the decrease of rainfall to the southward for a number of principal points in the valley:

Table of Rainfall on the East Side of the Great Valley of California.

Redding	34.60	Lathrop	11.88
Red Bluff	23.79	Modesto	9.57
Chico	20.91	Merced	10.30
Nicolaus	18.55	Fresno	9.02
Sacramento	19.80	Tulare	7.00
Galt	16.72	Bakersfield	6.08
Stockton	13.18		

Apart from the decrease of rainfall to the southward there is also a diminution from the eastern border of the valley toward the axis, and at some points even to the foot of the Coast Range on the western border. Thus, Chico on the eastern border has nearly 21 inches; Orland, in the same latitude, but on the western edge of the valley, 16 inches; Marysville, on the east, 18.9; Colusa, in the axis, 16.24; Williams, on the west, 13.32 only. Tehama, only ten miles south from Red Bluff, has not quite 16 inches against 23.79 at the former place. Of course, local conditions with respect to prevailing air currents have much to do with such discrepancies, which, however, do not invalidate the general conclusions.

Roughly speaking it may be said that the increase of alkali runs parallel with the decrease of rainfall in the valley; it is at its maximum near the south end, at its minimum near the north end, which in fact it does not reach. So far as its prevalence to an injurious extent is con-

cerned, it practically ends, east of the Sacramento River, at or near the city of Sacramento, with an average rainfall of nearly 20 inches. Here the proximity to the base of the Sierra foothills exerts a disturbing influence, for we find at Marysville, forty miles farther to northward, but also farther out in the valley, only 18.9 inches of rainfall. Local conditions prevent the accumulation of alkali salts east of the Sacramento River at this latitude; but immediately across on the west side, all the heavier lands are alkaline, and so, with a rainfall of about 16 inches, continue, decreasingly, nearly to the head of the valley near Tehama.

To southward in the San Joaquin Valley, likewise, there is a general increase of alkali in the soil to westward, and in some regions clear to the foot of the Coast Range. The reason is, in part, the scanty drainage from that range, and the fact that the (tertiary) beds forming the immediate slopes are charged with both alkaline and earthy salts, and thus combine to increase the saline contents of the soils independently of climatic conditions; so that even the waters of many streams are in summer undrinkable. From similar causes, limited alkali areas exist locally even near the coast, where the rainfall is in excess of 20 inches.

While, therefore, it cannot be rigorously said that a certain rainfall conditions in all cases the alkalinity or non-alkalinity of soils, it certainly appears that in California at least, 20 inches of rainfall is the upper limit beyond which the retention of any considerable amount of soluble salts in the soil becomes impossible under ordinary conditions of soil and drainage; while below that limit, the degree of alkalinity is dependent more or less upon local conditions as well as soil texture, and may or may not reach the point at which these salts become of serious import to agriculture.

Alkali Lands in Oregon and Washington.—If we extend the inquiry to other regions, notably to Eastern Oregon and Washington on the north, where the climatic regime is similar to that of the "Franciscan" region of California, modified mainly by the greater cold of winter, we still find the same rule to hold good. There also the bulk of the rain or snow falls in the six months from November to April inclusive, the rest of the year being practically rainless so far as any efficiency toward the leaching out of soluble soil ingredients is concerned. This is especially true of the portions of these States lying between the Cascade range on the west and the western branch of the Rocky Mountains (the Coeur d'Alene ranges) on the east, the Spokane River on the north, and the Blue Mountains on the south; excepting, of course, that portion which, on account of its proximity to the eastern chain, already enjoys a proportionally increased rainfall (to wit, the Palouse and Walla Walla country), and like Northern California can produce annual crops without irrigation. Perhaps there is no part of the United States so severely afflicted with an excess of alkali salts near the surface, as is the southern portion of what is known as the "Bend" country in Washington (Great Plain of the Columbia), with its lakes and streams of alkali water. Yet the northern half of the region is not only well suited to agriculture, but is actually rendered more so, in part, by the presence of a *moderate* amount of alkali salts. For the rainfall of this region we as yet have no data except the popular statement that it is "awfully dry" in the alkali region of the southern portion; while an increase toward the north must, apart from the successful cultivation, be inferred from the increase

of timber as we approach the Spokane, and the fact that beyond that stream pine forests at once set in. The precipitation at Fort Spokane, not far from the junction of the river with the Columbia, is however only about 12 inches; at Ellensburg, on the upper Yakima (west of the Columbia and farther to the southward), 9 inches; and, judging from the character of the vegetation, there is even less on the lower Yakima. Throughout this region alkaline efflorescences occur on most of the lower lands; while the rolling lands, owing to the pervious (silty) character of the soils, are generally free from any noticeable taint. Fort Simcoe, lying to southward at the northern foot of the partly wooded range which borders the Columbia River to northward of The Dalles, has over 13 inches, doubtless on account of that proximity; but to eastward the forest soon terminates and the range abuts on the Yakima plain completely bare of tree growth, and largely even of shrubs, with a rainfall ranging mostly between 7 and 14 inches.

Central Montana affords an interesting field of study in respect to the limitation of alkali by the amount of rainfall. Here the city of Helena occupies nearly the same relative position toward the Rocky Mountains as does Sacramento toward the Sierra Nevada; and the rainfall of the two cities is almost identical, being close to 20 inches. Owing to the location on a slope, no alkali appears within the city; but, as at Sacramento, it comes to the surface in the trough of the plain, to northward; and, with decreasing rainfall, becomes more and more conspicuous and troublesome as we descend the Missouri toward Fort Benton; the maximum being reached (together with the minimum of rainfall so far as known—6.95 inches) in the region about Fort Shaw, on Sun River, a western tributary of the Missouri. Here, again, the perviousness of the silty soils makes the existence of alkali salts less apparent on the surface; but it becomes disagreeably obvious in the water of the springs, lakelets, and small streams of the region. East of the Missouri, the several groups and chains of mountains surrounding the Judith Basin modify the conditions of precipitation to a considerable but not as yet accurately recorded extent, leaving the northern part of that basin almost free from alkali land; but the southern portion, as well as the slopes toward, and valley of, the Musselshell River, are scarcely anywhere entirely free from the alkali taint. Toward the Yellowstone drainage area there is a gradual decrease of salts, and in the Yellowstone valley itself alkali ceases to be a matter of practical interest.

These examples suffice to show that while the presence of alkali is dependent upon a certain sufficiency of rainfall, yet that fact alone does not necessarily imply its presence to any practically important extent; the greater or less perviousness of the soil and of the sub-strata, as well as a certain slope of the surface, being effectual in counteracting the accumulation. Nevertheless, as the table of soil-composition shows, such deficiency remains potent everywhere in bringing about the main characteristics of the soils of the arid region, to wit: high percentages of lime, magnesia, and potash, and, relatively, of soda.

Alkali Lands of India.—In India we find, in the Indo-gangetic plain, a large area in which alkali ("reh") is more or less troublesome to cultivation; extending all the way from the Indus and the Arabian Sea to a little beyond the Ganges, and from the Gulf of Cutch in the south to Afghanistan on the north; including all of Sindh, Rajputana, the plains of the Punjab, the Northwest Provinces, and part of Oudh, to

within a short distance of the Himalaya ranges; including Lahore. Within this vast region the rainfall varies from a minimum of 4.3 inches in Jacobabad, on the Afghan frontier beyond the Indus, to over 30 at Cawnpore on the Ganges. We have but very scanty data as to the extent to which alkali salts prevail to an injurious extent within this area; all the provinces mentioned above are reported as suffering from "reh" more or less; but, singularly enough, the one region in which the evil has caused the appointment of a government commission to invesgate its causes and remedies, is the one which, from the amount of rainfall, one would have supposed to be exempt from alkaline efflorescences. This is the country bordering upon the rivers Jumna and Ganges, and includes the important cities of Delhi, Meerut, Agra, and Cawnpore. It is doubtless because of this fact, and of the high value of the land created by the extensive irrigation canals deriving their water from the two rivers, that the subject has here attracted such attention. The minimum rainfall occurs at Aligarh (24.3 inches), with 28.5 at Meerut and 27.6 at Delhi on the north, 26.5 at Agra and 26.7 at Etawah on the south. All these figures are materially above what in the arid region of North America appears to be the upper limit permitting of alkali efflorescences, viz.: 20 inches or thereabouts; and the question as to the cause of this difference is of considerable interest, the more as no complaints of trouble with "reh" seem to come from the Deccan, in southern India, where the same average rainfall of 24 to 30 inches prevails.

A study of the distribution of the rains through the year seems to account for the inefficacy of the rains in leaching the soil of the Northwest Provinces of its surplus salts. Unlike the "Franciscan" type of climate, in which nearly all the rainfall is concentrated within a consecutive period of six months, during which the soil is constantly kept wet enough to permit of percolation downward, the rains of northwest India fall more or less in all months of the year save November, but usually in such small amounts that no percolation is brought about; save that in the months of July and August nearly half of the annual precipitation comes down in torrential form, ill calculated to produce more than a wetting of the soil to a depth whence capillary rise will again carry the soluble salts to the surface. In the Deccan (south-central India) the distribution of the rains is less abrupt, keeping up more or less from March to December inclusive, and with fewer torrential downpours. How little the latter can do toward removing the alkali salts is strikingly apparent even in Washington and Montana, where summer thunder storms sometimes cause a sudden rise of the streams, quickly followed by dry stream beds. Such rains are as powerless to act upon the alkali in the soil as are the often repeated attempts to remove even the superficial efflorescences by quick and brief flooding. The first touch of the water dissolves the salts, and the dry soil beneath instantly absorbs the solution, leaving the bulk of the water to flow by uselessly.

While to this extent the occurrence of alkali salts in India differs somewhat from that in North America, all the rest of the characteristics of the "reh-plague" are the same in both countries, and, so far as data are available, everywhere in the world. Unfortunately, the records, even of the geological survey of India, supply but scanty details in regard to the facts, although a good deal of discussion is had, from which we glean cursorily the main features of the case. The calcareous nature of the

"reh" soils, and their tendency to form hardpan or "kankar," which aggravates the evil, are referred to in connection with the leaching-out of the carbonate of lime from the higher slopes. The fact that the bottom water is frequently charged with salts, while deeper wells are free from any unusual taint, is mentioned in connection with the effects of irrigation; the undoubted fact that irrigation has increased the reh area is referred to, but the connection with the high-lying canals is called in question, because (as stated) no sensible dilution of the soil water has apparently taken place. Those who are familiar with the corresponding results of an exactly similar situation in California, will hardly be disposed to concur in this doubt. As regards composition, also, the exact substances constantly found in our arid regions are mentioned; only considerably greater stress is laid upon the occurrence of nitrates, and nitrate (!) of lime is mentioned as a possible good antidote for the carbonate of soda. It is not easy to see, from our point of view, how a sufficient amount of so expensive a salt should be procured for practical purposes, and why the cheap and abundant sulphate (gypsum) is not preferred in the recommendation.

Turning to *other countries* of notably deficient rainfall from which data in point are available, we find in Egypt, Arabia, Syria, and Persia, as well as in the Aralo-Caspian plains, to the northern borders of Afghanistan, a state of things quite analogous to that of the arid regions of North America and India. Soils of extraordinary and lasting fertility when irrigated; a frequent mention of calcareous hardpan or tufa on the part of observant travelers; saline efflorescences as obstacles to cultivation; saline bottom waters, barely drinkable in the shallow wells which alone the natives have found energy enough to dig: these are matters of constant mention, but too frequently attributed to the evaporation of supposed ancient salt-water basins. The climatic data available from these countries are mostly too scanty to determine what, in each of them, is the limit of rainfall beyond which alkaline salts cease to become apparent on the surface. It is interesting to note, in examining the records, how nearly the seasonal distribution and amount of rain credited to Jerusalem agrees with the "Franciscan" climate of Central California; about 22 inches falling from November to April inclusive; enabling crops to grow without irrigation and preventing the accumulation of alkali salts to any injurious extent.

I am not aware that the subject of alkali lands, and the conditions of their existence and reclamation, have attracted the attention of the *French colonies* on the African coast quite as much as the manifest importance of the subject would seem to justify. The "shotts" on the northern edge of the desert seem to be regarded as hopeless alkali sinks only, from which to obtain soda for technical uses, as is also done in Fezzan.

Pretty much the same indifference appears in Europe, in the *Hungarian Plain*, where the gathering of "shekso" or crude soda, rather than cultivation, seems to be the destiny of the alkali lands. Popularly the light and heavy varieties of these lands are distinguished as "szek" and "szik" respectively. With a rainfall of about 24 inches, these lands differ from the ordinary alkali lands in that their salts are supplied them from a saline stratum below the subsoil, instead of being generated in the soil itself; in other respects, however, the phenomena and the practical outcome are identical, including even the extreme productiveness of the

heavier soils close to the border of spots incrusted with salts. The latter vary, as in California, from almost pure carbonate to mixtures of Glauber's and common salt, which have in the past formed articles of commerce. Without doubt the same processes of reclamation are applicable to them as those which are proving so successful in the case of the alkali soils of California; and the attention of the Hungarian government has been awakened by the results obtained in this State.

COMPOSITION OF ALKALI SALTS IN DIFFERENT REGIONS.

In order to show the nature and possible functions of the alkali salts in soils I give below a table of analyses, selected from a large number, to show the great variety, as well as certain coincidences of composition, wherever found.

It will be seen that all over the world the saline efflorescences occurring over wide acres and owing their existence to general causes, have as their prominent ingredients the three sodium salts—*chlorid* (common salt), *sulphate* (Glauber's salt), and *carbonate* (sal soda). The relative proportions of these vary greatly, especially as regards the chlorid and carbonate; the sulphate is on the whole the one most invariably present in considerable proportion. In addition to these we find, usually in relatively small proportions, what might be called accessory ingredients, depending more or less upon local conditions, climatic as well as geological, but frequently of very great practical importance. Among these, the salts of potassium (potash), the nitrates, and the phosphates are of particular interest to agriculture, since they represent three elements usually supplied in fertilizers; whence it follows that their presence in the soluble form in such proportions as to participate in the formation of alkali crusts on the surface, is of no mean interest to the farmer, since it argues the occurrence of an excess of plant food in the soil, and therefore the needlessness of fertilization while this state of things continues.

It is therefore of special interest to determine to what extent the presence or absence of these accessories is dependent upon climatic conditions, and what local conditions may modify the result.

Nitrates.—Of the accessory ingredients the one most manifestly dependent upon climatic conditions is the nitrates. It is well known that the process upon which their formation depends is materially conditioned upon a certain high temperature (about 75° Fahr.); a moderate degree of moisture, permitting the easy access of air and forbidding the existence of reductive fermentations; the presence of calcic or magnesic carbonate; and most of all, upon that of the "nitrifying organism," without which the other conditions are powerless to act. Anything that paralyzes or destroys that organism is fatal to nitrification.

Among the ingredients that might be considered as certainly injurious to the life of the organisms in question are the chlorids of calcium and magnesium (bittern), and the carbonate of soda (and potash) when present in any large proportion, *e. g.*, so as to dissolve the humus of the soil, forming what is familiarly known as "black alkali." We should therefore expect to find nitrates scarce or absent where large percentages of carbonate of soda are found in the alkali salts, and relatively abundant when sulphate and chlorid are chiefly present. Actual examination fully confirms this *a priori* conclusion; the occurrence of

NOTE.—To facilitate comps
of the efflorescences, exclusive

Compound	
Potassium sulphate (K_2SO_4	
Sodium sulphate (Na_2SO_4)	
Sodium carbonate (Na_2CO_3	
Sodium chlorid (NaCl)	
Sodium phosphate (Na_3PO_4	
Magnesium sulphate (MgS(	
Magnesium chloride (MgCl	
Totals	

*Also called "kara," i. e., "

Composition of the Soluble Alkali in Foreign Localities.

NOTE.—To facilitate comparison, all the analytical data given in the following tables have been recalculated so as to show the composition of the soluble portion of the efflorescences, exclusive of gypsum, where present. In many cases potash, nitrates, and phosphates were doubtless present, but were overlooked.

Compounds.	Europe.		Asia.					Africa.			Australia.	
	Hungarian Plain, "szekso."		Plain of the Araxes.			Aden, "hurka."*	India, "reh."	Egypt, "trona."		Fezzan, "trona."	Bendigo, "alkali."†	
	Kalocsa.	Debreczin.										
Potassium sulphate (K_2SO_4)							11.1				1.28	1.63
Sodium sulphate (Na_2SO_4)	.2	1.6	10.4	18.2	15.5		7.0	23.6	38.3	.6	40.05	
Sodium carbonate (Na_2CO_3)	48.1	92.5	14.7	12.1	69.0	67.2	79.0	28.2	47.7	98.7		
Sodium chlorid (NaCl)	51.7	4.4	74.6	69.7	15.5	32.8	2.9	48.2	14.0	.7	47.47	81.88
Sodium phosphate (Na_3PO_4)		1.5										
Magnesium sulphate ($MgSO_4$)											11.20	9.86
Magnesium chloride ($MgCl_2$)												6.73
Totals	100.0	100.0	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.00	100.10

*Also called "kara," *i. e.*, "black alkali." † Bulletin No. 14, Department of Agriculture, Victoria, page 18.

nitrates in large proportion is confined to those regions in which "white alkali" is predominant; that is, neutral salts whose presence does not injure the activity of the nitrifying organism. This is confirmed also by the fact that the niter-beds of South America, as well as those of Nevada (White Plains) contains the saltpeter associated only with the two neutral salts, sulphate and chlorid of sodium. The same rule will be observed to hold good in the cases in which nitrates are found in notable amounts in the alkali salts from California and Montana, of which analyses are given above. No nitrates are found in the highly carbonated salts of Washington.

We have thus in the necessarily calcareous nature of the soils of the arid region the fulfillment of one necessary condition of ready nitrification; in the moderate moisture-condition of the soils of the same region, a favoring condition so far as oxidation is concerned, together with the substitution of eremacausis of the soil humus in the place of the fermentations that under humid conditions frequently not only arrest all oxidation but also, by the formation of poisonous compounds (ferrous and manganous salts), actually destroy the life of the nitrifying organism. Even the exceptional condition of a strong impregnation with carbonates of the alkalies does not act as unfavorably upon plant nutrition as might be inferred, for it is apparent from the analytical record as well as from the evidences of the senses, that in that case the evolution of ammonia from the humus can serve as a source of direct supply to vegetation; and finally, whatever nitrates are formed are not, as in humid climates, liable to be leached currently from the soil beyond the reach of plants, but remain year after year in actual accumulation. We are thus justified in the conclusion that aridity is peculiarly favorable to the supplying of nitrogen to plants.

Potash.—While the presence of this substance is to some extent dependent upon the character of the country rock, being often very high where granites contribute largely to the soils; yet its accumulation in the soils themselves seems to follow, as a matter of course, along with, and in preference to, the sodium salts; the cause of the difference being its more tenacious retention by the soil. As regards the water-soluble salts, it is probable that where no potash appears in the analysis of an alkali salt, it has simply been overlooked or neglected. It will be noted that in California and Montana potash salts frequently constitute from 7 to 10 per cent of the whole mass of "alkali"; forming a supply that, when calculated to the soil mass to the depth to which the roots of crops are likely to reach, promises to defer indefinitely the need of supplying potash fertilizers to such soils. There does not appear to be any definite relation between the amounts of potash present and the neutral or carbonated condition of the salts.

Phosphoric Acid, or Phosphates.—The slight solubility of earthy phosphates of necessity relegates the abundant occurrence of soluble phosphates to the cases where the salts are highly carbonated; it is therefore chiefly in the very "black" alkali that we find notable amounts of dissolved (sodic) phosphate. But in some cases these amounts are sufficient to promise the farmer, as in the case of potash salts and nitrates, a long exemption from the purchase of phosphate fertilizers.

In view of these facts it seems abundantly worth while to examine carefully the conditions under which the two types of alkali salts—the neutral, or "white," and the alkaline (carbonated), or "black"—respect-

ively occur, and to what extent we may be able to control their injurious effects upon vegetation.

Formation of Natural Deposits of Carbonate of Soda.—It is curious to search in the past and even current literature on the general subject, for a reasonable explanation of the occurrence of carbonate of soda in nature. There seems to be a consensus of opinion that the carbonation of the soda is in some way connected with the presence of limestone or carbonate of lime, and that an exchange has occurred in which either common salt or Glauber's salt have transferred their acidic components to lime and have become carbonates instead. But how such an exchange is to be effected, in view of the exactly opposite reaction that occurs when alkali carbonates and earth sulphates or chlorids are brought in contact in our laboratories, has led to many wild conjectures without a tangible basis.

Yet the simple explanation of the contrary reaction was given and published as early as 1826, by Schweigger; in 1859 it was again observed by Alex. Müller, in a different form; but neither these chemists, nor any of their readers, appear to have perceived the important bearing of this reaction, not only upon the formation of the natural deposits of carbonate of soda, but also upon a multitude of processes in chemical geology.

Without going into detail, which has been published elsewhere,* it may be broadly stated that the formation of carbonated alkalies occurs whenever the neutral alkaline salts (chlorids or sulphates) are placed in presence of lime or magnesia carbonates *and* carbonic acid, or of alkali "super-carbonates" (hydro-carbonates) containing even a slight excess of carbonic acid above the normal carbonate; being the actual condition of all natural "sodas." In that case, crystals of gypsum may be seen, *e. g.*, in the residue from the evaporation of a mineral water which nevertheless shows a strong alkaline reaction; and such alkaline reaction is also obtained when carbonic gas is passed into a solution of common salt in which calcic carbonate is kept suspended, the formation of calcic chlorid being simultaneous with that of the alkali hydro-carbonate.

It is easy to see that these conditions are constantly being fulfilled in nature; for the decay and fermentation of vegetable matter is constantly progressing in soils, swamps, and lakes, and as evaporation progresses the alkaline carbonate crystallizes out on the surface, or margins, while gypsum or calcium chlorid accumulates on the bottom, or in the waters.

It has been shown above that the soils of arid regions are almost necessarily calcareous, free carbonate of lime being present; as are also the salts of the alkalies. The conditions for the formation of carbonates of the alkalies just recited, are therefore fulfilled wherever enough of vegetable decay (or evolution of carbonic gas from other causes) goes on so as to impart even a slight excess of carbonic acid to the soil or other water; and thus "black alkali" is formed, to an extent depending upon the excess of carbonic acid available for the process. It is evident that this excess will be greater in moist, close soils, rich in humus, than in loose and pervious ones; and thus the fact that "black alkali" is mainly found in low ground, and in rather close soils, finds a ready explanation.

* Proceedings of the American Association for the Promotion of Agricultural Science, for 1888 and 1890.

But since vegetable decay is essentially dependent upon a certain elevation of temperature, and is totally suppressed by a certain degree of cold: it follows that, other things being equal, the formation of the alkaline carbonates will be most abundant in warm climates. The record of the occurrence of the "soda" deposits that in time past were of such industrial importance as the only sources of sodic carbonate, answers fully the requirements of this condition. Egypt, the African arid region generally, Mexico, the Aralo-Caspian lowlands, Turkestan, and the arid regions of western India, are the well-known sources from which the supplies of the "mineral alkali" (Trona, Urao) were formerly obtained. Were not the reaction limited to relatively dilute solutions,* its cheapness would soon drive all other processes of soda manufacture out of existence.

We do not therefore ordinarily expect to find alkaline carbonates abundant in the colder portions of the arid region; and this, as the table shows, is pointedly true as regards Montana. But in Washington, practically in the same latitude, the showing is quite different; we find here not only the carbonate of soda predominant, but it is present in percentages as high as those which in Montana and California are shown by the Glauber's salt.

But examination also shows, in the case of Washington, a special cause for this state of things. Almost the entire area on which alkali occurs in that State is covered by the black eruptive rocks commonly, although to a great extent improperly, called basalts. As eruptives, these rocks are, of course, entirely free from gypsum, and but very rarely show even a trace of sulphurets. There is therefore no source from which sulphates could derive their essential ingredient; and thus the sodic carbonate originally formed in the decomposition of the basalt by the atmospheric agencies simply continues unchanged, as it emerges with the spring waters from the crevices of the rocks. Yet in a few cases, where the basaltic eruptives are overlaid by a somewhat considerable mass of stratified (cretaceous and tertiary) deposits, the sodic carbonate is in the minority, and as in Montana, the sulphate predominates.

That such local accidents as these should bring about apparent contradictions is to be expected; yet even in this case they prove the rule.

In the summary review of the relation of climate to soils—the two factors which essentially control the production of the necessaries of life—that forms the subject of this paper, the scantiness and incompleteness of the data thus far available on a topic as interesting theoretically as practically important, is painfully apparent; and to no one more so than to the writer himself, who has made soil studies a favorite pursuit during most of his active life. While the intrinsic difficulties to be met in such an investigation are sufficiently great, the remarkable looseness of observations bearing upon it, their usually sporadic and unsystematic nature, and the fact that they are so thinly scattered in various kinds of literature: travels, geography, statistics, reports on geological, topographical, and even botanical topics, together with encyclopedias and miscellaneous technical works of reference, renders their collation and elaboration very laborious, and thus far rather unsatisfactory. It should not therefore be surprising to any one if in this first attempt at a systematic exposition of the subject there are many impor-

* The limit is reached at about 0.4 per cent.

tant gaps and omissions that might have been avoided had a more complete library and a larger share of leisure been at command. It may be hoped, however, that this paper may serve at least the purpose of enlisting in the study of this, the latest phase of chemical geology, a larger number of active workers and observers, so that at least, the large amount of information actually existing may be gathered together and made practically useful; thus leading the way to a better understanding of the character, capabilities, and needs of the lands of the various regions, and of the means of utilizing them to the best advantage. The eminently practical nature of such investigations should commend them to greater attention from public geological surveys, in which a vast amount of labor is devoted to subjects of very much less interest and importance, whether theoretical or practical. The apathy that has prevailed in regard to these studies would be difficult to understand but for two considerations, one historical, the other intrinsic. From the latter point of view, the undeniable difficulty and complexity of the subject of soil study, and the want of immediately brilliant and remunerative results to the worker, is no mean deterrent factor. Historically, direct soil-investigation received a set-back in the early part of this century, when upon extravagant expectations from its application to agriculture there followed a reaction which has not even yet subsided entirely. But it certainly is high time that such prejudices should give way to a reasonable reconsideration of the facts from a modern scientific standpoint; and that in the prosecution of public surveys, the interests of agriculture should cease to be the stepchild of which the name is used only for the sake of conciliating the favor of the large class dependent upon its intelligent prosecution. Conjointly with the study of soils that of climatic conditions is of the utmost practical and theoretical importance; and ample means for the prosecution of both branches of study should be provided. The Experiment Stations of the United States, as now constituted, have not the means for a sufficiently rapid and energetic prosecution of either, to respond to the demands made upon them. Meteorological stations must be made much more numerous, and should largely be located with reference to the agricultural problems to be determined in connection with them. Actual field surveys to define the agricultural subdivisions and to study their peculiarities, should be made by parties covering ably not only the agricultural, but also the meteorological, geological, and botanical aspects of the several problems. This will be but simple and tardy justice to the fundamental industry upon which the very existence of nations depends everywhere.

II. ALKALI AND ALKALI SOILS.

The study of alkali soils, and especially of the methods of reclamation and the cultural value when reclaimed, has continued to engage considerable time and attention. As cultivation and irrigation in the interior valleys of California are extended, the inconvenience of having culture areas interrupted by streaks or spots of alkali land, and the expansion of alkali areas under irrigation, attract more and more attention to the need of dealing in a definite manner with the subject. Moreover, the rise of the alkali in consequence of irrigation, in lands before entirely free from any indication of the kind, is liable to cause not only inconvenience, but serious loss, in the older settled regions.

Since it has been conclusively shown that the vast majority of alkali lands when reclaimed become both highly and lastingly productive in consequence of the extraordinary amounts of soluble mineral plant food present in them, attention has been drawn to considerable areas which, while lying convenient to railroad communication, have heretofore been neglected because of the obvious presence of alkali. The Station has frequently received requests for the examinations of such soils, in order to determine their fitness for reclamation and culture; and thus it has become necessary to determine more closely both the amount and kind of alkali salts compatible with the welfare of the several culture plants. In the progress of such investigations, it has become apparent that this question is very much more complex than had been anticipated; since not only the indefinitely varying proportions of the total alkali salts in the soil, and of the several ingredients amongst themselves, but also the physical nature of the soil (closeness, looseness, heaviness, lightness, sub-soil conditions, depth and nature of bottom water, etc.) have to be taken into consideration. Among the latest difficulties encountered is the unexpected fact, definitely demonstrated by the investigation of Mr. Colemore, given below, that the alkali salts may vary very materially, *horizontally*, within one and the same "spot," as well as vertically, as heretofore shown. The causes and extent of these remarkable differences have yet to be ascertained and studied in a more general manner.

It is to be hoped that those directly interested in the reclamation of alkali lands, or in the prevention of the damage to plantations already established, will lend their aid in supplying information and specimens toward these studies, discarding the reticence which many have heretofore deemed it necessary to observe regarding the occurrence of alkali on their lands. The fabled ostrich in hiding its head in the sand to escape its pursuers, might claim an equal degree of foresight and prudence.

A number of analyses already completed are omitted from the present record, as their discussion will be more fruitful in connection with other work now in hand.

E. W. H.

THE AMOUNT AND KIND OF SOLUBLE SALTS PRESENT IN DIFFERENT PORTIONS OF AN ALKALI SPOT, FROM THE CENTER TO THE CIRCUMFERENCE.

By CHARLES COLEMORE, of San Francisco, U. C., 1894.

The object of the present series of investigations was to determine the amount and kind of alkali in an alkali spot which would injure plant life. Beginning at the central portion of such a plot and advancing toward the edges, we find the following conditions: At the center there is no vegetation whatever, while at a point near the edge vegetation begins to appear, and finally we reach a point where the growth is normal. Such are the physical aspects of an alkali spot of the type known as black alkali, and would seem to indicate a variation in the chemical composition of the alkali in the soil; the present investigation goes to show that such a variation does exist.

Samples for examination were taken to a foot in depth from an alkali spot near the Tulare Experiment Station, by the foreman, and at a distance of 4 feet from each other, so as to represent as nearly as possible a cross-section of the tract. In the following table, No. 1 represents the central part of the spot, while No. 5 was taken on the outer edge, where alfalfa and wheat were growing.

An inspection of the table will show that there is a decrease in the amount of sodic carbonate from 35.50 in the center to 23.86 in soil No. 5 or outer edge. This is the most deleterious of the salts present in "black alkali" regions, as it keeps organic matter in solution and corrodes and burns the roots of all growing vegetation. In soils Nos. 1, 2, and 3 it exists in quantities sufficient to almost totally prevent the germination of seed, while in soils Nos. 4 and 5 seeds germinate and grow. Culture tests on the samples showed that of the ten wheat seeds planted in soil No. 1, only one germinated, and that grew to be only one half an inch high when it withered and died. In soils Nos. 2 and 3 nothing grew, while in No. 4 seven of the ten seeds germinated and grew fairly well. In soil No. 5 eight or nine grew and flourished, producing better and earlier plants than in No. 4.

The amount of organic matter held in solution, though variable, shows a general decrease from No. 1 to No. 5, while the sulphuric acid increases regularly from No. 1 to No. 5, and being combined with potash and soda to form neutral salts it renders the alkali more bland and non-corrosive.

TABLE I.

Amount of Soluble Matter at Various Points of the Section of Alkali Spot. (First foot in depth.)

Samples Taken.	Total, Inclusive of Organic Matter.	Mineral Salts.
No. 1, center of spot	0.679	0.377
No. 2, next to center	.539	.397
No. 3, intermediate	.697	.535
No. 4, next to outer edge	.370	.250
No. 5, outer edge of spot	.337	.229

TABLE II.

Percentage Composition of Soluble Alkali in Various Portions of Alkali Spot.

	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potassic sulphate	4.69	7.09	9.60	10.93	11.11
Sodic sulphate	13.89	9.53	19.10	18.37	13.51
Magnesic sulphate	2.15	.02	.77	1.57	6.61
Sodium chlorid	9.65	17.61	19.42	18.57	23.66
Sodic carbonate	35.50	37.81	30.24	27.20	28.86
Sodic phosphate	3.90	2.14	.70	.....	.83
Sodic nitrate	.22	Not deter.	.69	Not deter.	.11
Organic matter	30.00	24.80	19.48	23.36	20.31

TABLE III.

Percentages of Inorganic Substances at Various Points of Alkali Spot.

	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potash	3.65	5.06	6.57	6.13	7.84
Soda	50.91	49.51	45.25	48.37	41.24
Magnesia	1.04	.09	.33	.68	.30
Chlorine	8.46	13.91	14.32	14.84	18.24
Carbonic acid	20.70	18.69	15.62	14.95	12.67
Sulphuric acid	14.18	14.48	20.17	18.31	22.99
Phosphoric acid	2.71	1.36	.36	.....	.52
Nitric acid	.20	Not deter.	.55	Not deter.	.09
	101.85	103.14	103.17	103.28	103.89
Less oxygen due to Cl	1.85	3.14	3.17	3.28	3.89
Totals	100.00	100.00	100.00	100.00	100.00

TABLE IV.

Percentage Composition of Alkali Salts. (Compounds calculated without organic matter.)

Mineral Salts.	No. 1. Center of Spot.	No. 2. Next to Center.	No. 3. Interme-diate.	No. 4. Next to Outer Edge.	No. 5. Outer Edge of Spot.
Potassium sulphate	6.70	9.55	11.92	14.26	13.95
Sodium sulphate	19.84	12.85	23.72	23.97	16.96
Magnesium sulphate	3.07	.07	.95	2.05	8.29
Sodium chlorid	13.80	23.73	24.12	24.23	29.69
Sodium carbonate	50.72	50.96	37.55	35.49	29.94
Sodium phosphate	5.57	2.88	.87	.....	1.04
Sodium nitrate	.30	Not deter.	.87	Not deter.	.13
Totals	100.00	100.00	100.00	100.00	100.00

COMMENTS ON THE RESULTS OBTAINED BY MR. COLEMORE.

In the investigations on the alkali question heretofore made at this Station, the great and, from a practical point of view, often very important differences in the nature of the alkali salts from neighboring tracts, have repeatedly attracted attention. Since from late observations it appeared that the composition of the salts differs at different depths even in one and the same spot, it became probable that even greater differences would appear if the composition at different horizontal points in one and the same spot were tested.

As is well known, the sporadic alkali spots found in level tracts are usually more or less basin-shaped, the center of the (usually approximately circular) spots being a few inches to a foot and even more below the general surface of the ground. The cause of this depression is the destruction of the flocculated or "crumby" structure of the soil (constituting "tilth") by the action of carbonate of soda, which consolidates the earth into compact, tough sheets of hardpan. As the "white" (neutral) alkali exerts no such effects, the existence of these depressions, and their extent, marks in a measure the intensity of the carbonate-of-soda plague.

Since in the case of rain or irrigation the tendency would be to wash the salts from the margin of the basin toward the middle, the fact shown in Table I, that the largest total amount of salts is found at or near the middle or lowest portion of the spot, was to be foreseen. Correlative with this we may expect to find a more or less regular decrease toward the margin, such as is shown in the table, until we reach, at that margin itself, the limit beyond which normal vegetation can not only exist without injury, but can render manifest by its luxuriance the extraordinary intrinsic productive capacity of the alkali soils.

It will be noted that this maximum amount here found to be compatible with ordinary (weed) vegetation is 0.23 per cent, or a little less than a quarter of one per cent of total soluble salts; of which, however, nearly one third was carbonate of soda, and nearly another third common salt; or nearly 0.08 per cent of the soil of each. This amount of carbonate of soda was found sufficient, in an adobe soil near Stockton,* to prevent tillage and any useful plant growth; while in the lighter soil of Tulare such growth *is* successful, notwithstanding the additional presence of an equal amount of common salt, which, as experience has shown, is much more injurious than Glauber's salt.

It is thus obvious that the mere determination of the *amount* of total salts present in a soil is not sufficient to determine its fitness or unfitness for crop growth; it is essential that the *nature* and *proportion* of the different salts present should be determined, before a definite judgment can be had.

Nature of the Alkali Salts at different Points of the Spot.—Tables II, III, and IV show the variations in the composition of the alkali salts from center to margin.

Table II is chiefly interesting as showing the various amounts of organic matter (here mainly humus or vegetable mold) dissolved by the different qualities of alkali salts. While not altogether regular in its increase from the margin toward the center, doubtless on account of differences in the nature of the matter dissolved, it is clearly apparent that the largest amount is dissolved by the alkali containing the largest proportion of carbonate of soda; as might have been foreseen.

Table III, in which the several mineral ingredients are set down in the form resulting from analysis, and Table IV, in which the elements are placed in their most probable combinations, show more plainly the important changes of composition from center to margin, because of elimination of the organic substance from the calculation. We thus obtain a very much more consistent series of figures for most of the ingredients. Most striking of all, perhaps, is the fact that while *soda*

*See Report of the College of Agriculture for 1879, p. 34; also separate issue of report on "Alkali Lands, Irrigation and Drainage," 1886, p. 9.

shows a steady increase (from nearly 41 to 51 per cent) from the margin toward the center, *potash*, on the contrary, shows the reverse progression, namely, an increase from 3.65 at the center to 7.84 at the margin. The cause of this reversal is, doubtless, the comparative slight solubility of potash sulphate as compared with sodic sulphate; from which there results a tendency to leave the potash salts behind. This explanation is corroborated by the figures for sulphuric acid and magnesia; the latter showing the wandering of the soluble magnesium chlorid toward the center, while the sulphates remain behind.

But perhaps the most important of the differences is shown by the figures for *carbonic acid*, which show a remarkably regular increase of the noxious carbonate of soda from the margin toward the center, where more than half of the total salts is this carbonate. A similar increase from the margin toward the center is noted for the phosphates.

Since the solubilities of carbonate and sulphate of soda do not differ very widely, this increase of carbonate must be due to some other cause. The true one is doubtless to be found in the greater degree of moisture which throughout the season exists toward the middle of the spot; favoring in a marked degree the formation of carbonic acid, which as I have heretofore shown* is in connection with lime carbonate, the active agent in transforming sulphates and chlorids of alkalies into carbonates. It is entirely parallel to the wider fact heretofore mentioned by me that "black" alkali is by far more predominant on low than on high ground; *e. g.*, in the flood plains of streams, as against the adjacent bench lands.

That *phosphoric acid*, or rather alkaline phosphates, should follow the same rule as the carbonate, I have also heretofore discussed in connection with the almost universal fact that neutral or "white" alkali salts usually contain only traces of phosphates. That strong solutions of alkaline carbonates should tend to decompose the earthy and metallic phosphates of the soils, so as to form alkaline hydro-phosphates, while no such action can be looked for from neutral salts, is obvious.

A glance at the data concerning *chlorine* exhibits a decrease from the margin toward the center even greater proportionally than in the case of potash, and less only in that of phosphates. It is fairly supposable that this decrease is in the main due to the slighter solubility of common salt as compared with Glauber's salt, so that while the latter is washed toward the center the common salt tends to remain near the margin.

As regards *nitrates*, the determinations, as far as they go, indicate that while they are leached from the margin toward the center, their absolute amount is not a maximum at the latter point, but about half way between. This is quite intelligible when we consider that not only must nitrification cease in presence of so excessive an amount of carbonate of soda, but that in addition the very process of fermentation, upon which (as above mentioned) the formation of that carbonate depends, may, by reduction, destroy nitrates already formed, and may even give rise to the formation of ammonia salts, the occasional presence of which in alkali soils has seemed so enigmatical.

From the practical standpoint the facts, as here shown, emphasize the need of more energetic measures in reclaiming the lower portions of

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*Alkali Lands, Irrigation and Drainage, p. 24.

ALKALI CORNER PREVIOUS TO THE GYPSUM EXPERIMENT. (All Alkali, but white spots much stronger.

alkali streaks in general, as compared with higher ground, whether in the more abundant use of gypsum to neutralize the black alkali, or more effective drainage for leaching out the surplus salts. (E. W. H.)

RECLAMATION OF ALKALI LAND WITH GYPSUM AT THE TULARE STATION.

By C. H. Shinn, Inspector of Stations.

The high degree of success which has now been gained with the alkali reclamation plots at the Tulare Experiment Station, justifies a review of the system pursued and the results obtained there. The illustrations annexed are reproduced directly from photographs. A few details might be shown better by drawings, but the accuracy and authenticity of the photographic process are incontestable, and accuracy in this case is all-important.

The experiment of reclamation was commenced in 1890, in the northeast corner of the Station tract, where the strongest alkali existed. Here, over about an acre, there was no vegetation, not even weeds, and all attempts to grow crops had wholly failed. Even in less strong alkali tracts adjoining this acre, beets, sorghum, and cereals could not be grown successfully. The experiment was therefore intentionally made upon the worst "alkali sink" in the region—a tract hard to duplicate, and containing much more of the "black alkali" (about two per cent) than would ordinarily occur in experiments upon a large scale.

Plot No. 1, as laid off in 1890 in this northeast corner, contained one fourth of an acre. It was cheaply underdrained by means of three redwood drains, shaped like an inverted V, and placed about three feet below the surface. These drains united, and discharged into a drainage-pit, or sump (shown in the photograph below), dug in the edge of a small, shallow slough, and carrying the water into the gravel beds beneath. Some system of drainage was made necessary upon this plot because of the intensity of the alkali, and its great extent, not only on the Station tract, but in adjoining fields. Mere surface treatment, without drainage, would have changed the nature of the alkali ("black" to "white"), but it would still have left in the soil too large a proportion of salts for the growth of any useful vegetation.

In constructing this drainage system, cheapness was important, and it was put into operation at a cash outlay of less than $50. On a larger scale, and in light or sandy soils, it could doubtless be done with more permanent materials and with an outlay of $30 per acre.

A second plot of three fourths of an acre, adjacent to Plot No. 1, was experimented with upon another plan. No sump nor underdrainage was used, but the hardpan was merely broken up with charges of blasting powder, at intervals of 10 feet apart, and at a total outlay of less than $10.

The effect of gypsum on the hard and tough clods of hardpan was well observed in this treatment. Shortly after the water was turned on so as to enable the gypsum to exert its influence, the clods began to soften and crumble off on the outside, and in a few days were transformed into piles of crumbs much more bulky than the original masses.

So far this method, at the Tulare Station at least, seems to have served nearly as well as the more costly underdraining with rough redwood, but in localities where the gravel lies deeper than 12 to 15 feet, drains of some sort would probably be necessary to reclaim alkali as strong as that under consideration.

The one fourth of an acre (Plot No. 1) was surrounded by an embankment, thrown up with plow and spade, and was divided for convenience in handling into two nearly equal parts, separated by a cross dike. The surface, which was extraordinarily hard and difficult to work, was plowed and deeply broken five times in 1890. Masses of the "hardpan" were pounded up with axe and crowbar. After each plowing gypsum was spread on the surface and harrowed in. Water was immediately turned on, and allowed to stand three inches deep over the plot for several weeks at a time; it gradually soaked down, and passed out into the sump, dissolving and carrying off the salts, while neutralizing the "black alkali." After the fourth plowing and treatment with gypsum, sugar-beets were sown, but the seed failed to germinate in the soil, still too strongly impregnated with alkali to carry any vegetation. This attempt to grow beets closed the season of 1890, during which gypsum had been used at the rate of 500 pounds to the acre. It was thoroughly incorporated with the surface foot of soil, and leached through the upper three feet of soil, to the level of the drains. None of it was wasted. Ten times as much, merely spread on the surface and left to the weather, would have been less effective than this small quantity worked into the soil.

The second and third years, 1891 and 1892, the same kind of treatment was extended to the larger plot, which had been prepared by blasting for drainage. It was observed that the operation of the gypsum was somewhat slower here, and that a larger amount was required, as it sank deeper where the blasts had been made, and hence wasted faster.

During 1891 and 1892 the original plot of one fourth of an acre was several times plowed, broken up with pick-axe and spade, dressed with gypsum, and irrigated, as before. It was still found that seeds would not germinate well, though the percentage of injurious salts was greatly lessened. In 1891 a few beets sprouted and made three or four pairs of leaves before they perished. A few barley spears grew one or two inches above the surface, turned yellow, and died. In the autumn of 1891 straw was freely plowed in to keep the soil from "running together" into a hard, almost impenetrable mass. Four workings in all the plot received in 1891, and four more in the following year, 1892.

The cultures attempted in the spring of 1892 were more varied than before, embracing beets, corn, sorghum, cereals, grasses, clovers, and some garden crops. Most of these were sown in short rows near the middle of the plot, and the rows received a special application of gypsum to better protect the seed. Results showed the effect of the underdrains; the nearer the plants stood to the line of a drain the better they grew. While many cultures failed entirely, there was much to encourage hopefulness. Sorghum and Egyptian corn in some cases grew six or seven feet high, and yielded heavily. Close beside such plants as these were others hardly three inches high, pygmies of the same age, stunted by the alkali. A few barley plants were normal, but most of them when headed out were only three or four inches high. It was evident that the leaching of the plot had been very uneven, owing to the

ALKALI CORNER OF TULARE EXPERIMENT STATION. (Alkali sump in foreground; reclaimed Alkali ground, with grain crop, in background.)

hardness of the soil; and most of the gypsum used in 1892 was used upon the spots where the alkali still remained strongest.

By the close of the year 1892 gypsum had been used on the plot at the rate of 2,000 pounds per acre, and it was thought to be time to make a field test on a larger scale. In December, the foreman, Mr. Forrer, plowed in all the straw the land would bear, and sowed wheat and barley the last week of the month for the crop of 1893. It proved to be a fair season in the district. No water was applied nor any more gypsum until after the crop was harvested. The straw plowed in kept the surface loose, and the grain germinated well. It grew rank and tall, excepting in two or three very small spots. The wheat yielded at the rate of 45 bushels to the acre, and the barley did even better. Some of the best stalks were nearly five feet high, and the average stand was four feet. The plot was visited by many farmers who said that there was no finer grain growing in the district, and acknowledged the success of the experiment. The photograph represents the plot as it appeared just before the grain was cut: One of the visiting farmers is sitting on the dike; the foreman is standing near. This grain was thus grown, after three years' treatment, upon the worst portion of the alkali corner of the Station tract—land that in a natural state produced nothing, not even weeds or pasturage. The grain was finally cut and specimens sent to the Central Station at Berkeley, where it is kept for illustration. They were also placed on exhibition at the Midwinter Fair in the station alcove of the University exhibit. The accompanying photograph gives the relative height and appearance of the several samples. At one end are also specimens of wheat from a medium alkali spot where the grain has just been able to grow to a few inches, while on adjoining plots it had attained a height of several feet.

Meanwhile, on the other plots, the three fourths of an acre where blasting powder had been used, the land was broken even more deeply than on Plot No. 1, by a process of trenching with plow and spade, and gypsum and straw were mixed with the soil. The leaching here proceeds more slowly than on the first plot, but good progress has been made, and another season a fair crop of wheat and barley can be expected.

The one-fourth acre plot was treated with another dressing of gypsum late in 1893, and, on December 20th, cereals were again sown there, and also upon the three quarters of an acre adjoining, where blasting powder had been used. A poorer crop was looked for from the latter, but it seemed desirable to see where additional applications of gypsum were necessary. All the seed started well, and grew fast until six inches high. The severe cold and drought of the disastrous spring of 1894 then checked, and finally destroyed all the grain on the three-quarters acre plot. Upon the smaller, and best reclaimed plot, a half crop was obtained, greatly to the surprise of the farmers, who had watched the experiment with especial interest on account of the untoward season. It would have been easy to have irrigated all the plots, but this would have destroyed the value of the test, under such climatic difficulties. The total rainfall was less than five inches, and the drying northers were very severe.

Summing up the work done in five years on this experiment: the total amount of gypsum used upon the acre now under treatment is 3,000 pounds. Only 625 pounds has gone on the first one fourth of an acre, which was underdrained. This was at the rate of one and one fourth

tons to the acre. The plots on which blasting powder was used have required 2,375 pounds of gypsum, or at the rate of nearly 3,200 pounds to the acre, and are not yet as far reclaimed as the first plot. They will probably require half a ton more to yield wheat and barley at the rate of last year's crop on Plot No. 1. The gypsum is evidently distributed more evenly and therefore more effectively by the method of underdraining, where the conditions are similar to those that prevail at the Tulare Station.

REMARKS ON THE ABOVE EXPERIMENT.

The above description of the reclamation experiment shows some of the characteristic points to be observed and difficulties to be encountered in the reclamation of alkali lands. It must, of course, be fully understood that the procedures here made use of were tentative and purely with a view to study, and without present reference to expense. As stated by Mr. Shinn, the spot chosen for the operations was probably as bad a case as could be found in the whole alkali region. The entire soil-mass had been consolidated ("run together") into compact sheets of impervious hardpan of puddled clay and fine sand; almost completely untractable under the plow, and even when reduced to something like tilth by main strength, returning to its original condition of compact, resistant, tough hardpan at the first wetting. Analyses had showed this hardpan to contain from 2 to 3 per cent of soluble salts; an amount by far too large, according to all experience had, to permit of either the germination or growth of any plant, especially so long as any considerable proportion (usually about one third) of these salts consisted of carbonate of soda. European experiments on coast marsh soils give one fourth of 1 per cent (0.25%) of salts as the limit consistent with useful cultures; in the present case we have to deal with ten times that amount of salts of a much more noxious nature.

Our observations have, however, long demonstrated that Glauber's salt, or sulphate of soda, exerts a much less noxious influence upon plant-growth than common salt; and since this is the compound formed from "black alkali" when neutralized with gypsum, the remarkable change in the producing power of land which was entirely useless in its unreclaimed condition, is readily intelligible.

In the pamphlet issued by the Station on this subject, and reprinted in 1892, special attention is called to the need of preventing surface evaporation, and the formation of a crust in which the alkali could accumulate, so as to injure the surface roots and root-crown, or to prevent germination of seeds. This is the obvious cause of the effectiveness of straw in aiding reclamation by means of gypsum or underdrainage; not because of any fertilizing effect, as has been imagined by some, who thought of improving upon straw by the use of stable manure in the same way.

It should be distinctly understood that wherever "black alkali" exists, the use of stable manure to effect the loosening of the soil may materially *injure* instead of improving the effect, by the setting free of corrosive ammonia vapors, which destroy the vitality of seeds. In none of the alkali lands thus far examined by us is there the slightest occasion for the addition of fertilizing ingredients, which are invariably present in the soluble salts themselves to an extent not only far exceeding that

On Medium Alkali. Partly Reclaimed Alkali Soil On Fully Reclaimed Alkali Soil.

WHEAT AND BARLEY GRAIN ON ALKALI LAND TREATED WITH GYPSUM.

supplied by any ordinary dose of fertilizer, but which, being perpetually supplemented from below, must for a series of years render all fertilization unnecessary. The high productiveness of alkali lands illustrated in the above experiments, and substantiated wherever the effects of the noxious salts have been done away with by under-drainage or gypsum treatment—illustrated in fact by the enormously rank growth of weeds on the edge of every alkali spot—is readily and strikingly explained by the analyses of alkali salts, given in the present as well as in previous reports.

It may not be superfluous to call attention here, once more, to the fact demonstrated by us fourteen years ago, that less than one tenth per cent of carbonate of soda or "black alkali" in a clay soil will render it unproductive and frequently untillable; while the corresponding amount of Glauber's salts formed when such soils are treated with gypsum, is completely innocuous. As there are very extensive areas of soils whose cultivation is at present rendered unprofitable by just such a slight taint of carbonate of soda, it follows that these same lands can be reclaimed for culture not only profitable, but exhibiting extraordinary productiveness, by the simple use of appropriate doses of gypsum, without underdraining, blasting, or other extraordinary precautions or costly operations.

The fact above noted, that gypsum will cause the alkali hardpan to soften and crumble, will be found effective in raising to the general level the sunken surface of spots of black alkali, besides gradually rendering it pervious to water even in the depths of the subsoil. The water-tightness of these hardpans is one of the greatest difficulties in the reclamation of such lands; but if gypsum be allowed plenty of time and water, it will frequently correct this trouble without any further effort on the part of the farmer. (E. W. H.)

ANALYSES OF ALKALI.

Leachings of two alkali soils, 2 miles northeast of Amedee, Lassen County, California; sent by Dr. T. R. Grindley. Soils irrigated from an artesian well.

	No. 1.		No. 2.	
Per cent soluble matter in soil		4.29		5.35
Percentage composition of soluble matter—				
Again soluble in water after evaporation		97.99		95.38
Insoluble in water after evaporation		2.01		4.62
		100.00		100.00
Salts permanently soluble—				
Sodium carbonate	22.73		29.86	
Sodium chlorid	41.10	97.99	29.00	95.38
Sodium phosphate	1.58		3.77	
Sodium sulphate, etc.	32.58		32.75	
Insoluble after evaporation—				
Calcium and mag. carb., calcium sulphate, etc.	.74		1.09	
Calcium phosphate	.68	1.42	.57	2.66
Silica		.59		1.96
Total		100.00		100.00
Total phosphoric acid		1.01		1.96

The above samples doubtless represent a surface layer or crust, and not the soil-mass itself, since an impregnation to the extent of 4 and 5 per cent is incompatible with even the hardiest vegetation. Probably the impregnation does not exceed one eighth or one tenth of the above amounts at the depth of one foot, as has been found to be the case in other portions of the same region. The large proportion of sodium carbonate ("black alkali") in the mixture of salts indicates the need of the use of gypsum for neutralization at all points where alkali now appears, and probably over the entire surface of this kind of soil. About the high fertility of these soils when reclaimed there can be no question, both from the actual experience had and from the composition of the soil of the region as given in a former report (1891–92, p. 26). The large proportion of soluble phosphoric acid shown in the above table should probably have been supplemented by corresponding amounts of potash and saltpeter, which unfortunately were not sought for at the time. The following analysis probably shows an average of the usual proportion of potash present in the alkali of the Honey Lake border.

Leachings of alkali crust, 1½ miles southeast of Amedee, Lassen County, T. 8 N., R. 16 E.; sent by Dr. T. R. Grindley.

Per cent of moisture in crust		9.44
Per cent soluble matter in crust		74.23
Percentage composition of soluble matter—		
Again soluble in water after evaporation		96.209
Insoluble in water after evaporation		.346
Organic matter		3.445
		100.000
Salts permanently soluble—		
Potassium sulphate	10.692	
Sodium sulphate	35.452	
Sodium carbonate	19.721	
Sodium chlorid	29.625	
Sodium phosphate	.719	
		96.209
Insoluble after evaporation—		
Calcium sulphate	.039	
Calcium phosphate	.005	
Ferric phosphate	.072	
Ferric oxid*	.088	
Magnesium carbonate	.110	
		.314
Silica		.032
Organic matter		3.445
Total		100.000
Total phosphoric acid		.347

* Doubtless in combination with humic substances.

Alkali deposit, from Honey Lake Valley, Lassen County, California; sent by H. A. Lennon, of Amedee.

	Native Salts. Percentage Composition.	100 Parts, Dissolved in Water and recrystallized, will yield—	
		Parts.	Percentage Composition.
Water	22.15		
Sodium carbonate	53.52	143.87	76.25
Sodium bicarbonate	6.47	7.24	3.83
Sodium sulphate (with small amount potassium)	15.55	35.26	18.69
Sodium chlorid	1.92	1.92	1.02
Calcium and magnesium salts	.14	.14	.07
Silica	.25	.25	.14
Borax	Trace.		
Totals	100.00	188.68	100.00

The second and third columns above show what can be obtained from the salts as sent, by dissolving and crystallizing. Thus, 100 pounds of the salts will make 188 of crystallized soda of the percentage composition given in the third column; that is, containing not less than 76 per cent, and possibly as much as 85 per cent, of the carbonate of soda, according to the care exercised in the crystallization. This material is said to occur in considerable quantities in the region.

Alkali from the Wildflower country; sent by Paoli Gypsum Company, of Selma, Fresno County. In the region in which Wildflower Post Office is situated, to westward of Kingsburg and Selma, there is a tract of country about 5 miles wide and 10 miles long, on which alkali salts are seen to a greater or less extent, sometimes continuously over large tracts, sometimes only in spots.

Four samples from different localities were sent, each representing the soil to the depth of 12 inches and the surface layer or crust, in which, by evaporation, the alkali has accumulated. Of these samples, the one least impregnated, No. 1, and the one appearing most strongly impregnated, No. 2, have thus far been examined in detail, the corresponding crust being used for the determination of the ingredients of the alkali, while in the soils only the total quantity was determined. The following table shows the result:

	Wildflower No. 1.		Wildflower No. 2.	
	Soil.	Crust.	Soil.	Crust.
Potassium sulphate	Very little.	Very little.	Very little.	
Sodium sulphate	Little.	14.24	6.33	16.92
Sodium carbonate	Little.		Traces.	47.02
Sodium chlorid	Mainly.	78.66	Chiefly.	35.18
Sodium nitrate	Traces.	6.92	Traces.	.88
		99.82		100.00
Percentage of alkali salts in soil	.075		.167	
Organic matter and chemically combined water	Some.	12.31	Consid'ble	22.28

It will be seen that these two samples differ very materially in the character of their alkali salts. No. 1 consists chiefly of common salt, with about 14 per cent of Glauber's salt and nearly 7 per cent of Chile saltpeter; while No. 2 contains only half as much common salt, and nearly half of it consists of carbonate of soda, with not quite 1 per cent of Chile saltpeter, and about 17 per cent of Glauber's salt. No. 1, therefore, is strictly a "white alkali," while No. 2 is very "black," and would, in its present condition, be by far the more noxious of the two. Treatment with gypsum, however, would reverse the conditions, and leave No. 2, with about two thirds of Glauber's salt, much milder than No. 1, with a corresponding amount of common salt. Since, however, No. 2 contains more than twice as much of total salts as No. 1, the average condition of the two might be considered about equalized by the gypsum treatment.

The larger proportion of Chile saltpeter in No. 1, while giving promise of long-continued productiveness without fertilization, shows characteristically, as compared with No. 2, the unfavorable influence exerted by carbonate of soda upon nitrification.

The proportion of potash in both these alkali salts is unusually small, but will, in connection with that contained in the soil-mass itself, doubtless suffice for a number of years without replacement. Phosphates are present in both salts in traces only.

Waters from the Duhring tract, five miles southwest of Fresno; sent by W. R. Nutting. On this tract, portions of which are affected by alkali, some experiments were made with reclamation by drainage. Redwood drains were laid at a depth of two feet with a slope toward a natural pond formed by the rise of bottom water since the neighboring lands have been subjected to irrigation. It being found that the bottom and sides of this pond were almost impervious to water as a consequence of the formation of an alkali clay hardpan, a well-hole was dug a few feet from the edge of the pond with a view of draining, it as well as the water from the redwood drains, into a porous substratum.

The water samples represent the state of things after the first irrigation following the underdrainage and digging of the well.

No. 1. Water left standing on the soil after flooding around the well. Sample is turbid, brown in color, and with odor of sulphuretted hydrogen.

No. 2. Water from a well three feet from a pond; after standing over night. It contained 45.5 grains of solid matter per gallon.

No. 3. Pond water in August. On evaporation it was found to contain 629.5 grains of solid matter per gallon.

No. 4. Water flowing from a drain; sample is dark brown in color.

	No. 1. Surface Water.		No. 2. Drain Water.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	45.61	7.82	174.76	29.92
Soluble in water after evaporation	18.22	3.12	153.68	26.31
Insoluble in water after evaporation	8.82	1.51	8.64	1.50
Organic matter and chemically combined water	18.57	3.19	12.44	2.13
The soluble part consists of—				
Sodium sulphate (Glauber's salt, etc.). Potassium sulphate	3.88	.66	10.57 31.31	2.00 5.37
Sodium chlorid (common salt)	5.66	.97	83.88	14.33
Sodium carbonate (sal soda)	8.68	1.49	27.92	4.61
The insoluble part consists of—				
Calcium and magnesium carbonates. Calcium sulphate (gypsum)	4.79	.82	8.29	1.42
Silica	4.03	.69	.35	.06

It will be seen that while the drain water carries by far the largest proportion of soluble salts (nearly 154 grains per gallon against 18 grains in the surface water), the alkali salts contained in it are comparatively "white" when contrasted with those of the surface water. In the latter nearly one half of the soluble salts is carbonate of soda, while the salts of the drain water contain less than one fifth. Whether this is due to local conditions or to the surface soil generally containing more of the carbonate, we can only conjecture.

Another notable difference is shown in the common salt, which forms over one half of the drain-water alkali while less than one seventh in that of the surface water.

The wide differences already alluded to in the composition of the alkali from one and the same tract are thus again illustrated.

As to the pond water, which has probably formed chiefly by the inflow of surface drainage, its intense alkalinity speaks pointedly of the water-tight nature of its bottom and sides, without which such concentration by evaporation could not have occurred. The notable fact that fully 20 per cent of the drain-water alkali is potassium sulphate (a salt worth in the fertilizer trade some 3 cents per pound) illustrates the enormous waste of precious soil ingredients which may be brought about by the leaching of alkali soils.

Alkali crust from the land of Dr. Perrin, Visalia, Tulare County, California; sent by D. G. Overall.

Per cent soluble matter in crust	32.388
Per cent moisture in crust	1.794
Again soluble after evaporation and ignition	29.542
Insoluble after evaporation and ignition	.774
Chemical water and organic matter	2.072
Total	32.388

Alkali in Crust.

	Percentage Composition.	Per Cent in Crust.
Sodium carbonate (sal soda)	1.25	.370
Sodium chlorid (common salt)	80.55	23.796
Sodium sulphate	10.10	2.982
Potassium sulphate	8.10	2.394
Totals	100.00	29.542

The amount of sal soda ("black alkali") in this crust is so small as to be almost harmless, while the large amount of potash salt renders it valuable to the soil. The amount present in the land cannot be estimated from the above analysis.

Alkali, from a ditch that passes through an "alkali knoll" near Miramonte, Kern County; sent by Geo. A. Raymond. Examination showed it to be almost pure sulphate of soda ("white alkali"), with very little common salt.

Alkali, from near Buena Vista Lake, southwest of Bakersfield, Kern County, California; obtained by leaching sample of soil; sent by J. H. McLaughlin, of Bakersfield.

Sodium chlorid (common salt) in soil	1.280
Sodium carbonate (sal soda) in soil	.053
Sodium sulphate (Glauber's salt) in soil	3.460

Qualitative analysis of this soil shows it to contain high per cents of lime and phosphoric acid.

If the above samples represent properly the soil-mass, such land could not be profitably cultivated without a partial leaching-out of the soluble salts.

Alkali soils, from 7 miles southwest of Bakersfield, Kern County; sent by U. D. Cross, of Berkeley.

Soils.	Sulphate of Soda.	Chlorid of Sodium.	Carbonate of Soda.
Sample No. 1	Considerable	0.015 per cent	Very small amount.
Sample No. 2	Small	0.023 per cent	Minute amount.
Sample No. 3	Considerable	0.122 per cent	Traces.
Sample No. 4	Traces	Traces	Traces.
Sample No. 5	Large	1.500 per cent	Very small amount.
Sample No. 6	Small	0.017 per cent	Minute amount.
Sample No. 7	Large	0.250 per cent	Small amount.
Sample No. 8	Very small	0.012 per cent	Traces.

The above data show that in the region sampled, the nature of the alkali salts is altogether of the milder type of "white alkali," consisting chiefly of Glauber's salt, or sulphate of soda; while the carbonate, or "black alkali," is present in minute proportions only.

Alkali, from Los Angeles; sent by W. J. Woodward.

No. 1, from the land of T. Wiesendanger, 8 miles southeast of Los Angeles, contains a large amount of carbonate of soda ("black alkali"), with considerable chlorid and sulphate of soda (common and Glauber's salts).

No. 2, from the land of R. D. List, 6 miles southwest of Los Angeles,

contains considerable chlorid and sulphate of soda ("white alkali") and traces only of the carbonate.

In the former case, treatment with gypsum would doubtless be necessary to make the land do its best under cultivation; while in the case of No. 2, gypsum would be of no special avail.

Leachings of samples of soils from Anaheim, Los Angeles County; sent by Frank J. Capitain, of Los Angeles.

	No. 1. Taken at 6 Inches.	No. 2. Taken at 18 Inches.	No. 3. Taken at 36 Inches.
Sodium carbonate in soil	.093	.106	.033
Sodium chlorid in soil	.042	.141	.010
Sodium sulphate in soil	.044	.033	.006
Totals	.179	.280	.049

Qualitative analyses of these soils show Nos. 1 and 2 to contain about the average amount of lime, with phosphoric acid above the average; in No. 3, the lime and phosphoric acid are about the average. The use of gypsum on these soils would doubtless be beneficial, although the amount of alkali salts present is not excessive.

Saline earth, sent by J. M. Fulton, of Reno, Nevada. Its composition is:

Earth and sand	40.2
Soluble salts	27.5
Moisture or water	32.3
	100.0

The soluble portion consists almost wholly of Glauber's salt or sulphate of soda, with small amounts of the sulphates of potash, lime, and magnesia. On leaching the crude mass and evaporating to crystallization, it would yield 62 per cent, or one half its weight, of a good commercial article of Glauber's salt.

Alkali crust from foot of Rubidoux Hills, near Riverside, Riverside County.

Alkali salts are not abundant in the neighborhood of Riverside, the upland being completely exempt from them; and but an insignificant amount is usually found even in the valleys. The analysis of the above salts was therefore made mainly for the purpose of determining the nature of the water-soluble substances leached out of uplands as a clew to their probable needs in fertilization. The Rubidoux being a granite range, like most of those surrounding Riverside, its washings must be considered fairly representative of those of the other ranges, and of the soils formed from them.

The soil from which these salts bloom out is a reddish loam with a base of granitic sand.

Alkali Crust, Rubidoux Hills, Riverside County.

Potassium sulphate	3.20
Sodium sulphate	84.32
Sodium carbonate	.50
Sodium chlorid	5.93
Sodium nitrate	1.11
Organic matter and chemically combined water	4.94
Total	100.00

The analysis shows this to be a "white alkali," the bulk of it being sulphate of soda or Glauber's salt, together with a little common salt, and a trifling amount of carbonate of soda. The alkali is therefore of a very mild type; and the fact that it contains over 3 per cent of sulphate of potash, and over 1 per cent of Chile saltpeter, but only a trace of phosphoric acid, suggests forcibly that the suggestions heretofore made in regard to fertilization at Riverside, to wit: First of all, to supply the phosphates, nitrogen next, and then lastly potash, the latter being the most abundant of the three important soil ingredients, rest on a solid basis of fact, though originally based only upon conclusions derived from the analysis of the soils; whose potash percentages range near 1 per cent, while phosphoric acid is, in almost all cases, close to the limit of deficiency.

III. ANALYSES OF WATERS, AND REMARKS ON WATER SUPPLY.

Analyses made by M. E. JAFFA and MARVIN CURTIS.

During the past season there have been about 75 samples of water sent in from various portions of the State for analysis. The majority of these were to be examined only as to their fitness for domestic and irrigation uses, while in a few cases where sewage contamination was feared, a special analysis was made for free and albuminoid ammonia.

A. STREAM AND LAKE WATERS.

Water from Penitentia Creek, Alameda County; sent by J. H. Flickinger, of San José. The sample was turbid and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.20	2.09
Soluble in water after evaporation	3.10	.53
Insoluble in water after evaporation	6.76	1.16
Organic matter and chemically combined water	2.34	.40
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.70	.12
Sodium chlorid (common salt)	.54	.09
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	4.66	.80
Calcium sulphate (gypsum)		
Silica	2.10	.36

This is an excellent water for both domestic and irrigation purposes.

Water flowing from a tunnel near Santa Barbara; sent by E. S. Sheffield.

"The tunnel has been driven 400 feet into the Santa Ynez Mountains, and the water from it keeps up quite a constant flow at about 4 miner's inches. It begins at the brink and level of a mountain stream flowing usually about 15 inches. Both creek and tunnel cross the formation (which here is tipped up and stands almost vertical) at right angles. The stratification is unbroken and composed of layers or walls of hard sandstone with dense shale beds alternating. Both shale and sandstone are slightly impregnated with sulphur and lime, probably from the waters."

The sample was clear and without odor or taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	35.63	6.10
Soluble in water after evaporation	15.48	2.65
Insoluble in water after evaporation	17.81	3.05
Organic matter and chemically combined water	2.34	.40
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	12.94	2.21
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	13.72	2.35
Calcium sulphate (gypsum)		
Silica	4.09	.70

While the total amount of mineral salts can hardly be regarded as excessive, yet the proportion of alkali sulphates (Glauber's salt, etc.) is too great to be used continuously for drinking purposes. These salts are too laxative in their nature for weak systems. For irrigation, the water can be safely used, especially on sandy or loamy soils.

Water from Tia Juana River, San Diego County; sent by J. R. Stearns, of Tia Juana. Analysis made by P. W. Tompkins, a student in the Agricultural College.

The water held suspended matter, but was without odor. It had the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	46.58	7.97
Soluble in water after evaporation	28.73	4.92
Insoluble in water after evaporation	8.16	1.39
Organic matter and chemically combined water	9.69	1.66
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	7.76	1.35
Sodium chlorid (common salt)	16.64	2.83
Sodium carbonate (sal soda)	4.33	.74
The insoluble part consists of—		
Calcium and magnesium carbonates	7.70	1.31
Calcium sulphate (gypsum)		
Silica	.46	.08

This water is sufficiently saline in character to make it unpalatable, and also contains quite a large amount of organic matter. But for these it would be unobjectionable for domestic uses. The combined presence of so much common salt and organic matter throws a suspicion on its purity and freedom from contamination.

Water from bed of San Diego River, California; sent by J. W. Clemens, of San Diego. Residue blackens considerably on heating.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	36.50	6.25
Soluble in water after evaporation	8.35	1.43
Insoluble in water after evaporation	16.88	2.89
Organic matter and chemically combined water	8.47	1.45
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.61	.10
Sodium chlorid (common salt)	4.64	.79
Sodium carbonate (sal soda)	3.10	.54
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	16.88	2.89
Silica	2.80	.48

The total amount of mineral salts in this water is not much above the standard; and as the greater part of this is of the earths (giving to the water a rather "hard" nature) the water can be safely used for nearly all domestic and for irrigation purposes. Boiling or the use of sal soda will remove the hardness.

B. SPRING WATERS.

Spring water from Plumas County; sent by Adolph Ekman, of Oroville. The sample is clear and without odor, but with an alkaline taste and reaction.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	86.58	14.83
Soluble in water after evaporation	43.12	7.39
Insoluble in water after evaporation	43.46	8.44
Organic matter and chemically combined water	Traces.	
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	14.59	2.50
Sodium chlorid (common salt)	2.04	.35
Sodium carbonate (sal soda)	26.49	4.54
The insoluble part consists of—		
Calcium and magnesium carbonates, chiefly, Calcium sulphates (gypsum) very small amount	43.16	7.39
Silica	.30	.05

The large amount of mineral salts, and especially of the soluble matter, condemns this water for domestic use; and the excessive amount of carbonate of soda is an additional reason for its rejection for irrigation purposes.

Water of the Piedmont Water Company; drawn from the pipes in the residence of D. R. Rae, of Linda Vista Terrace, Oakland. The sample was clear, tasteless, and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	19.92	3.42
Soluble in water after evaporation	4.97	.85
Insoluble in water after evaporation	10.80	1.85
Organic matter and chemically combined water	4.15	.71
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.59	.62
Sodium chlorid (common salt)	.14	.02
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	8.76	1.50
Calcium sulphate (gypsum)		
Silica	2.04	.35

The water also contains 0.164 parts of free ammonia and 0.110 parts of albuminoid ammonia per million, which show some contamination from organic matters, but this can probably be removed by filtration. The mineral salts are within the limits of potable waters. The hardness due to the earthy carbonates can be obviated by boiling or by addition of a small amount of quicklime, say 5 grains per gallon.

Water from the Samuel Soda Spring, Napa County; sent by J. R. Morris, of Alameda. Sample was clear and odorless. Its composition was:

	Grains per Gallon.
Total residue by evaporation	85.86
Soluble in water after evaporation	40.89
Insoluble in water after evaporation	32.12
Organic matter and chemically combined water	12.85

The soluble part consists chiefly of bicarbonate of soda, with some chlorid and sulphate of soda, and a small amount of sulphate of potash. The insoluble part consists mainly of carbonate of lime and magnesia, with small quantities of gypsum. A spectroscopic examination showed the presence of lithium, strontium, and boracic acid. Free carbonic acid gas was present in considerable quantities.

Mineral spring waters from Alum Rock Park, on San José city reservation, Santa Clara County; from the Park Commissioners.

No. 1, from the soda spring, was clear, alkaline in character, and with a sweetish taste.

No. 2, of the "blue" sulphur spring, has an odor of sulphuretted hydrogen.

No. 3, of the white sulphur spring, has also an odor of sulphuretted hydrogen.

No. 4, a water with a strong saline taste or "salt condiment."

	No. 1. Soda Spring.	No. 2. Blue Sulphur Spring.	No. 3. White Sulphur Spring.	No. 4. "Salt Condiment."
	Grains per gallon.	Grains per gallon.	Grains per gallon.	Grains per gallon.
Silica	1.21	1.19	1.30	3.52
Potassium sulphate	.83	3.27	3.08	5.88
Potassium bicarbonate	10.57			
Sodium chlorid	126.94	73.68	38.89	146.67
Sodium bicarbonate	267.12	159.45	115.44	25.11
Sodium sulphate		13.68	13.77	116.51
Lithia (with spectroscope)	Slight test.	Slight test.	Very slight test.	Trace.
Magnesium chlorid	.50			
Magnesium sulphate		.39	.31	24.30
Magnesium carbonate	7.45	5.00	7.81	15.45
Calcium carbonate	20.82	19.52	12.98	19.91
Calcium sulphate	.18	.20	1.03	56.39
Calcium phosphate	3.04	1.17	.97	.32
Iron and alumina (carbonates and phosphates)	.35	.49	.29	.58
Boracic acid (with spectroscope)	Well marked test.	Well marked test.	Well marked test.	Well marked test.
Totals	439.01	278.04	195.87	414.64
Free carbonic acid gas, cubic inches per gallon	215.62	174.03	98.50	22.35
Free hydrogen sulphide gas, cubic inches per gallon		5.60	10.31	

The above table proves that these are carbonated saline waters, Nos. 2 and 3 containing also some free hydrogen sulphide gas. While possessing some medicinal properties, the amount of mineral matter found in each is so great, notably so in Nos. 1 and 4, as shown by the totals (439.01 and 414.64, respectively), as to entirely prohibit the adaptability of any of them for either household purposes or irrigation. The strength of these waters in mineral contents will be better appreciated when it is stated that 40 grains per gallon is the extreme limit which, according to Wanklyn, an ordinary drinking water should contain. As regards the medicinal properties, physicians are the proper judges.

Water from the Mountain Spring Water Company's mains, Los Gatos, Santa Clara County; sent by C. M. Merriam, Superintendent. The sample had no odor, and was clear and colorless. Its composition was as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.54	2.15
Soluble in water after evaporation	2.22	.38
Insoluble in water after evaporation	7.93	1.36
Organic matter and chemically combined water	2.39	.41
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.10	.02
Sodium chlorid (common salt)	.27	.04
Sodium carbonate (sal soda)	1.85	.32
The insoluble part consists of—		
Calcium and magnesium carbonates	7.35	1.26
Calcium sulphate (gypsum)		
Silica	.58	.10

The water is unusually low in mineral ingredients for the Santa Clara Valley, and no fault can be found with it for any use whatever, save that, like all waters of the region, it is somewhat hard.

Another sample of the water sent for examination was clear and tasteless, and contains but 11.7 grains of mineral salts per gallon. Of this amount 4.0 grains is carbonates of lime and magnesia, with a little silica. The remainder consists chiefly of common salt with small amounts of chlorids of calcium and magnesium, and of sulphate of potash. It is an exceptionally pure water, resembling river waters in composition. It contains less than half the average of earthy matters usually found in the well and spring waters of the Coast Ranges, and is of course admirably adapted to all domestic uses.

Waters from four springs in San Buenaventura, Ventura County, sent by F. Hartmann. The samples were all clear. No. 1 had a light straw color, was slightly alkaline, with a taste and odor of sulphuretted hydrogen. No. 4 had an earthy taste and was slightly alkaline. The others were free from taste or odor. No. 5 is a sample sent at another time.

	No. 1.		No. 2.		No. 3.		No. 4.		No. 5.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	118.34	20.26	605.14	103.60	723.13	123.80	433.06	72.14	283.82	48.59
Soluble in water after evaporation	115.64	18.60	524.07	89.72	613.43	105.02	291.99	49.70	193.93	33.20
Insoluble in water after evaporation	2.69	.46	35.74	6.12	38.56	6.60	65.42	11.20	60.16	10.30
Organic matter and chemically combined water	7.01	1.20	45.33	7.76	71.14	12.18	65.65	11.24	29.73	5.09
The soluble part consists of—										
Sodium and potassium sulphates (Glauber's salt, etc.)	103.81	17.77	518.92	88.93	602.34	103.12	282.87	48.44	186.09	31.86
Sodium chlorid (common salt)	2.73	.47	2.05	.35	6.14	1.05	1.63	.27	7.22	1.24
Sodium carbonate (sal soda)	2.10	.36	3.10	.44	4.95	.85	7.49	.99	.62	.10
The insoluble part consists of—										
Calcium and magnesium carbonates, etc.	2.22	.38	31.89	5.46	38.21	6.54	64.84	11.10	59.11	10.12
Calcium sulphate (gypsum)										
Silica	.47	.08	3.85	.66	.35	.06	.58	.10	1.05	.18

Considerable Epsom salt was also found in Nos. 1, 2, and 4. The very large amount of mineral salts, and especially of sulphates, in all of these waters, condemns them for all uses, both domestic and irrigation.

C. COMMON WELL WATERS.

Well water from two wells which are the source of water supply for Marysville; sent by Norman Rideout. One of the wells is 80 feet, and the other 180 feet in depth. The water of the two wells was combined in one sample. On evaporation this yielded 21.6 grains of mineral salts per gallon, an amount within that usually considered safe for domestic uses. An examination for organic impurities gave the following result: Chlorine, 1.80 grains per gallon; free ammonia, 0.013 parts per gallon; albuminoid ammonia, 0.088 parts per million. The water is therefore quite free from sewage contamination, and can be used with safety.

Well water from Placer County; sent by H. H. Bowman. Sample clear and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	13.87	2.38
Soluble in water after evaporation	2.78	.48
Insoluble in water after evaporation	8.47	1.45
Organic matter and chemically combined water	2.62	.45
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.53	.26
Sodium chlorid (common salt)	.95	.16
Sodium carbonate (sal soda)	.30	.05
The insoluble part consists of—		
Calcium and magnesium carbonates	4.32	.74
Calcium sulphate (gypsum)		
Silica	4.15	.71

The mineral contents of this water are so small that it cannot take rank otherwise than as a good domestic water; rather unusually pure. The gas is nitrogen, one of the constituents of air, and entirely inert.

Well water from Pixley, Tulare County; sent by B. G. Lathrop. The sample was clear and without odor or taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	10.51	1.80
Soluble in water after evaporation	5.84	1.00
Insoluble in water after evaporation	2.10	.36
Organic matter and chemically combined water	2.57	.44
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.07	.35
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	3.09	.53
The insoluble part consists of—		
Calcium and magnesium carbonates	.93	.16
Calcium sulphate (gypsum)		
Silica	1.17	.20

The water is exceptionally pure, and, of course, well adapted for all purposes.

Well water from A. C. Vandivier, of Firebaugh, Merced County. The sample was clear and without odor, but had a salty taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	207.12	35.46
Soluble in water after evaporation	81.54	13.96
Insoluble in water after evaporation	95.09	16.28
Organic matter and chemically combined water	30.49	5.22
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc., some Epsom salts)	76.34	13.07
Sodium chlorid (common salt)	3.96	.68
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	92.99	15.92
Calcium sulphate (gypsum)		
Silica	2.10	.36

For domestic uses this water is too highly charged with mineral salts, and especially of the soluble sulphates (Glauber's and Epsom salts) to be thought of for a moment. For irrigation purposes, though quite free from carbonate of soda (black alkali), there would be a rapid accumulation of salts, which on most soils would soon prove injurious.

Well water from east of Porterville; sent by C. Talbot, of Tulare. The sample was clear and colorless, and had the following composition:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	15.77	2.70
Soluble in water after evaporation	8.17	1.40
Insoluble in water after evaporation	5.79	.99
Organic matter and chemically combined water	1.81	.31
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.97	.70
Sodium chlorid (common salt)	1.98	.32
Sodium carbonate (sal soda)	2.22	.38
The insoluble part consists of—		
Calcium and magnesium carbonates	4.50	.77
Calcium sulphate (gypsum)		
Silica	1.29	.22

This water is a good one for all ordinary uses, whether domestic or agricultural. It has no special medicinal qualities.

Well water from a well 300 feet in depth, located in Sec. 5, T. 15 S., R. 13 E., Fresno County; sent by N. C. Briggs, of Hollister. The sample sent was clear, tasteless, and without odor.

	Grains per Gallon.
Total residue by evaporation	176.98
Soluble in water after evaporation	127.92
Insoluble in water after evaporation	31.54
Organic matter and chemically combined water	17.52

The soluble part consists chiefly of common salt with the sulphates of soda and potash and carbonate of soda. The insoluble part comprises the carbonates of lime and magnesia, sulphate of lime, and silica. The amount of mineral salts present renders this water totally unfit for either domestic or irrigation purposes.

Water from Kern Land Company. Analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	71.84	12.30
Soluble in water after evaporation	34.22	5.86
Insoluble in water after evaporation	27.80	4.76
Organic matter and chemically combined water	9.82	1.68
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	29.03	4.98
Sodium chlorid (common salt)	2.72	.46
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	25.94	4.44
Silica	1.86	.32

The water is too heavily charged with mineral matter for most domestic uses; it would act as a purgative upon most persons, if used repeatedly. For irrigation it is also too heavily charged, unless the land were leached at least every other year by long-continued flooding. It contains over eleven times as much alkali salt as Kern River water.

Well water from Happy Valley, Humboldt County; sent by M. R. Jager. The sample was clear and without taste or odor.

	Grains per Gallon.
Total residue by evaporation	2.57
Soluble in water after evaporation	.87
Insoluble in water after evaporation	1.18
Organic matter and chemically combined water	.52
The soluble part consists of—	
Sodium and potassium sulphates (Glauber's salt, etc.), Sodium chlorid (common salt), chiefly, Sodium carbonate (sal soda)	.87
The insoluble part consists of—	
Calcium and magnesium carbonates, Calcium sulphate (gypsum), chiefly	.99
Silica	.19

This water is remarkably pure and free from mineral salts, and can of course be used for almost any purpose.

Well water from Sonoma; sent by Mrs. M. A. Johnson. It is from a well 10 feet deep. The sample was turbid, and with a slightly earthy taste. The sediment consisted almost entirely of ferric oxid, with some silica.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	12.79	2.19
Soluble in water after evaporation	2.33	.40
Insoluble in water after evaporation	8.24	1.41
Organic matter and chemically combined water	2.22	.38
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	.43	.07
Sodium chlorid (common salt)	.04	.01
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonate, chiefly, Calcium sulphate (gypsum), small	2.22	.38
Silica	6.02	1.03

When filtered this water is very pure, and suitable for all domestic and irrigation purposes.

Well water from East Oakland; sent by F. Bieler. Analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory. Sample tasteless and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	27.45	4.70
Soluble in water after evaporation	11.68	2.00
Insoluble in water after evaporation	10.52	1.80
Organic matter and chemically combined water	5.25	.90
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.15	.21
Sodium chlorid (common salt)	6.82	1.16
Sodium carbonate (sal soda)	3.71	.63
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	8.18	1.40
Silica	2.34	.40

Sanitary Analysis.

Total solids	27.450 grains per gallon.
Chlorine	4.160 grains per gallon.
Free ammonia	.032 parts per million.
Albuminoid ammonia	.064 parts per million.
Oxygen consumed by moist combustion	3.500 parts per million.

This water, while very hard, is unobjectionable in other respects for domestic use, and shows no sign of outside contamination.

Well water from well 50 feet deep; sent by Frank Silva, of Pleasanton, Alameda County.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	18.34	3.14
Soluble in water after evaporation	6.54	1.12
Insoluble in water after evaporation	6.83	1.17
Organic matter and chemically combined water	4.97	.85
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.67	.29
Sodium chlorid (common salt)	1.77	.30
Sodium carbonate (sal soda)	3.10	.53
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	5.49	.94
Silica	1.34	.23

The water is sufficiently weak in mineral salts for domestic use; but for irrigation purposes on lands where drainage waters cannot percolate and pass off freely, there would be a slow accumulation of the carbonate of soda, which in a few years would threaten a case of "black alkali."

Well water from North Berkeley, Alameda County; sample furnished by W. E. Magee. Water clear, colorless, and odorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	103.62	17.74
Soluble in water after evaporation	63.90	10.94
Insoluble in water after evaporation	14.60	2.50
Organic matter and chemically combined water	25.12	4.30
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	10.27	1.78
Sodium chlorid (common salt)	51.15	8.74
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	11.50	1.97
Calcium sulphate (gypsum)		
Silica	3.10	.53
Nitrates	Traces	only.

	Parts per Million.
Free ammonia	.040
Albuminoid ammonia	.328
Oxygen consumed by moist combustion	3.150

Residue does not blacken on heating.

This water, which is very hard, is unfit for domestic purposes, owing to its high mineral contents and contamination with organic matter.

Well waters from East Oakland, Alameda County; sent by Wm. Rutherford. Both samples were clear.

	No. 1. Grains per Gallon.	No. 2. Grains per Gallon.
Total residue by evaporation	59.00	391.94
Soluble in water after evaporation	49.76	365.83
Insoluble in water after evaporation	5.73	9.93
Organic matter and chemically combined water	3.51	16.18

The *soluble part* of both waters consists mainly of common salt with small quantities of the sulphates, and traces of bromides, iodides, and borates of soda and potash.

The *insoluble part* comprises chiefly the carbonates of lime and magnesia, with small amounts of gypsum and silica.

The presence of the bromides and iodides may class these waters as medicinal in character, but otherwise the amount of other mineral salts condemns them for domestic uses.

Water from well 13 feet in depth, located on Sec. 21, T. 11, R. 11; sent by C. J. Welch, of East Oakland. The sample was clear, and salty to the taste.

	Grains per Gallon.
Total residue by evaporation	3240.65
Soluble in water after evaporation	3087.03
Insoluble in water after evaporation	28.04
Organic matter and chemically combined water	125.58

The enormous amount of residue per gallon shown by this analysis is chiefly of common salt, which makes it a natural brine, and, of course, totally unfit for any use except the manufacture of salt.

Well water from the Judson Iron Works, Oakland; sent by P. Wagner. The works are located on the shore of the bay of San Francisco. The sample has no color, taste, nor odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	25.99	4.45
Soluble in water after evaporation	13.67	2.34
Insoluble in water after evaporation	8.23	1.41
Organic matter and chemically combined water	4.09	.70
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.46	1.46
Sodium chlorid (common salt)	2.73	.47
Sodium carbonate (sal soda)	2.48	.41
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	7.94	1.36
Silica	.29	.05

There were also found a trace of free ammonia, 0.036 parts per million of albuminoid ammonia, and 0.600 of oxygen consumed. While practically free from sewage contamination, as well as from direct influx of brackish water, the mineral ingredients are a little above the limits desired for domestic use, though not enough so as to condemn the water.

Water from well in Lorin, Alameda County; sample furnished and analyzed by A. V. Stubenrauch, a student in Agricultural Laboratory. The well is 80 feet deep. The sample was clear and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	20.44	3.50
Soluble in water after evaporation	6.54	1.12
Insoluble in water after evaporation	8.36	1.43
Organic matter and chemically combined water	5.54	.95
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	3.32	.57
Sodium chlorid (common salt)	1.36	.23
Sodium carbonate (sal soda)	1.86	.32
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	6.78	1.16
Silica	1.58	.27

A sanitary analysis showed a trace of free ammonia, 0.076 parts per million of albuminoid, 0.920 of oxygen consumed, and 0.830 of chlorine.

The above water is sufficiently pure in every respect for domestic uses. The amount of mineral salts is within the limits of potable water, and especially so as it consists largely of lime and magnesium carbonates.

Well waters from Jacob Mueller, of Oakland, Alameda County. Each sample was clear and free from odor or taste.

	No. 1.		No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	28.33	4.85	28.20	4.83
Soluble in water after evaporation	10.22	1.75	10.45	1.79
Insoluble in water after evaporation	16.18	2.77	15.77	2.70
Organic matter and chemically combined water	7.30	1.25	6.83	1.17
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	7.89	1.36	8.19	1.41
Sodium chlorid (common salt)	1.09	.18	1.02	.17
Sodium carbonate (sal soda)	1.24	.21	1.24	.21
The insoluble part consists of—				
Calcium and magnesium carbonates Calcium sulphate (gypsum)	8.88	1.52	8.94	1.53
Silica	7.30	1.25	6.83	1.17

The waters are very similar in contents and character, and both may be regarded as fit for domestic uses, though rather high in mineral salts. The hardness due to the earthy carbonates may be corrected by boiling or by the use of a little sal soda or quicklime.

Well waters from the place of Jacob Mueller, of Oakland. One was from an old well 40 feet deep; the other from a well near Peralta and Thirty-sixth Streets, Oakland, 48 feet deep. The sample from the first was clear and colorless, but had an unpleasant odor. The residue from evaporation blackens considerably on heating. The sample from the well 48 feet deep was clear and colorless. The waters had the following composition, respectively:

	Old Well, 40 Feet.		Well 48 Feet.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	88.97	15.23	20.44	3.49
Soluble in water after evaporation	53.04	9.08	8.23	1.40
Insoluble in water after evaporation	16.97	2.93	9.23	1.58
Organic matter and chemically combined water	18.96	3.22	2.98	.51
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	29.29	5.02	3.15	.54
Sodium nitrate, small quantity.				
Sodium chlorid (common salt)	21.28	3.64	1.36	.23
Sodium carbonate (sal soda)	2.47	.42	3.72	.63
The insoluble part consists of—				
Calcium and magnesium carbonates Calcium sulphate (gypsum)	16.27	2.81	6.66	1.14
Silica	.70	.12	2.57	.44

The water of the first is unfit for domestic use from its composition alone, apart from the intrinsic evidence of its septic character afforded by the large contents of common salt and organic matters, which point to sewage contamination. The water of the 48-foot well is quite "hard,"

but otherwise quite unobjectionable; there is no reason to suspect it of sewage contamination.

Well water from Berkeley, Alameda County; sent by Robert Dugan. The sample was found to contain more than 100 grains of solids per gallon, which renders it entirely unfit for use.

Well water from East Oakland; sent by James Dowling, corner East Fifteenth Street and Thirteenth Avenue; analyzed by W. L. Dunn, of Oakland, student in Agricultural Laboratory. Sample in good condition, without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	41.47	7.10
Soluble in water after evaporation	24.01	4.11
Insoluble in water after evaporation	12.26	2.10
Organic matter and chemically combined water	5.20	.89
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	1.08	.19
Sodium chlorid (common salt)	20.46	3.50
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	9.40	1.61
Silica	2.86	.49

This water contains a large proportion (nearly one half) of common salt, and is also very hard in character. It must be suspected of contamination, and is unfit for domestic use.

Well water from Haywards, Alameda County; sent by J. J. Booth. The analysis was made by P. W. Tompkins, of San Francisco, a student in the Agricultural College. The sample held suspended matter, had an odor of sulphuretted hydrogen, and a flat, woody taste; also a milky color. Its composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	29.20	5.00
Soluble in water after evaporation	10.17	2.74
Insoluble in water after evaporation	9.98	1.71
Organic matter and chemically combined water	9.05	1.55
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.88	1.18
Sodium chlorid (common salt)	.82	.14
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	6.89	1.18
Silica	3.09	.53

The residue blackens on ignition. The water contains rather more mineral matter than is usual in the region, yet not enough to render it medicinal, or objectionable for domestic use. On some persons it might have a slight aperient effect. The sulphur odor is probably connected with the large amount of vegetable matter found; it would be advisable to clean out the well thoroughly, and this would probably disappear.

Well water from J. W. Strandberg, of De Forrest, Santa Clara County. The sample was clear and had a taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	30.89	5.29
Soluble in water after evaporation	11.09	1.90
Insoluble in water after evaporation	16.64	2.85
Organic matter and chemically combined water	3.16	.54
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	7.25	1.24
Sodium chlorid (common salt)	1.36	.22
Sodium carbonate (sal soda)	2.48	.42
The insoluble part consists of—		
Calcium and magnesium carbonates	14.31	2.45
Calcium sulphate (gypsum)		
Silica	2.33	.40

This is a potable though very hard water, and for other domestic purposes can be improved by boiling and settling, which would remove the hardness due to the earthy carbonates. It is also suitable for irrigation purposes.

Well water from William Pfeffer, of Gubserville, Santa Clara County. Water contains suspended matter, probably clay.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	35.87	6.14
Soluble in water after evaporation	7.00	1.20
Insoluble in water after evaporation	18.77	3.21
Organic matter and chemically combined water	10.10	1.73
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.76	.47
Sodium chlorid (common salt)	1.77	.30
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates	16.65	2.86
Calcium sulphate (gypsum)	.25	.04
Silica	1.87	.32

Residue blackens slightly on heating.

The mineral salts in the above consist largely of the earths, and do not injure the water for irrigation. For domestic uses where such very "hard" water is objectionable the earths can be removed by boiling.

Sanitary analysis of sample of water from well on public school lot at Saratoga, Santa Clara County; sent by James Fablinger, Clerk of Board of School Trustees.

"The well is 40 feet deep, and the source of the water is in a clay soil, near the base of the mountain. In sinking the well a bed of hardpan, or white clay, was passed through; at the base of the mountain the rock is a limestone. About ten rods east of the well is a swale, or bog, and the village cemetery is about 50 or 60 rods above, on a gentle slope. The water-closets of the school-house are about 100 feet away from the well, and complaint has been made that seepage enters the well and produces disease. The well is bricked up on the sides and bottom."

Water slightly turbid. Residue blackens but slightly on heating. A trace of nitrates present.

Total solids	16.700 grains per gallon.
Chlorine	.250 grains per gallon.
Free ammonia	.011 parts per million.
Albuminoid ammonia	.092 parts per million.
Oxygen consumed	1.200 parts per million.

The water contains rather an unusually small amount of soluble matters of any kind, and the organic part (ammonia, etc.) is so small in amount that there is certainly at present no sewage contamination.

Well water from Cayucos, San Luis Obispo County; sent by Rev. S. Slocombe. The sample was clear, but had a brackish earthy taste and was alkaline in character.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	162.96	27.90
Soluble in water after evaporation	85.69	14.67
Insoluble in water after evaporation	31.13	5.33
Organic matter and chemically combined water	46.14	7.90
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	2.02	.37
Sodium chlorid (common salt)	81.82	13.98
Sodium carbonate (sal soda)	1.85	.32
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	30.84	5.28
Silica	.29	.05

The water is too highly charged with mineral salts to be used for any domestic or agricultural purpose. The high amount of earthy carbonates present make it a very "hard" water.

Well water from Saticoy, Ventura County; sent by M. T. Wells. The sample was clear and tasteless, but had an odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	169.39	29.00
Soluble in water after evaporation	89.69	14.50
Insoluble in water after evaporation	64.26	11.00
Organic matter and chemically combined water	20.44	3.50
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	72.79	12.57
Sodium chlorid (common salt)	10.91	1.76
Sodium carbonate (sal soda)	.99	.17
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum), chiefly	64.02	10.96
Silica	.24	.04

The large amount of mineral salts in this water renders it totally unfit for either domestic or irrigation purposes.

Water from Piru, Ventura County; sent by Leslie F. Gay. The sample was clear and without taste or odor. It contains but 2.04 grains of mineral salts per gallon, and is of such exceptional purity that a further examination is not necessary.

Well water from Tres Pinos, San Benito County; sent by Mrs. A. F. Anderson. Sample tasteless, odorless, and colorless.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	146.36	25.06
Soluble in water after evaporation	126.22	21.61
Insoluble in water after evaporation	11.09	1.90
Organic matter and chemically combined water	9.05	1.55
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	62.99	10.81
Sodium chlorid (common salt)	54.56	9.32
Sodium carbonate (sal soda)	8.67	1.49
The insoluble part consists of—		
Calcium and magnesium carbonates	9.17	1.57
Calcium sulphate (gypsum)		
Silica	1.92	.33

The analysis shows the water to be of a decidedly purgative nature, and contains far too much mineral matter for use for domestic purposes in general.

Well water from Ventura; sent by Jones & Son, druggists. Analyzed by W. L. Dunn, of Oakland, a student in Agricultural Laboratory. Water contains a small quantity of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	82.71	14.16
Soluble in water after evaporation	55.08	9.43
Insoluble in water after evaporation	21.50	3.68
Organic matter and chemically combined water	6.13	1.05
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	49.14	8.43
Sodium chlorid (common salt)	4.09	.69
Sodium carbonate (sal soda)	1.85	.31
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	17.65	3.02
Calcium sulphate (gypsum)		
Silica	3.85	.66

This water has the composition of a great number of well and spring waters in Ventura and Santa Barbara Counties. Its prominent ingredient is Glauber's salt, or sulphate of soda, which is a saline laxative, and there is enough of it in this water to act in that way, and to benefit persons needing it, but entirely too much for domestic use; viz., about five times as much as is found in good well waters. The salts are practically the mixture known as "white alkali."

Well water from Montalvo, Ventura County; sent by O. P. Cook.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	515.82	88.31
Soluble in water after evaporation	246.20	42.15
Insoluble in water after evaporation	168.22	28.80
Organic matter and chemically combined water	101.40	17.36
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	125.57	21.55
Sodium chlorid (common salt)	113.21	19.33
Sodium carbonate (sal soda)	7.42	1.27
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	153.62	26.30
Calcium sulphate (gypsum)		
Silica	14.60	2.50

This water is far too heavily charged with mineral matter for any but medicinal use as a purgative; stock might drink of it for the salty taste, but it would be very injurious if often repeated. There is no way to reduce the mineral contents to an unobjectionable figure, although the earthy carbonates could be gotten rid of by boiling, or by the use of lime. There would still remain ten times more saline matter than is considered admissible for drinking.

Water from a well 2 miles southwest from the city of Santa Barbara, on the property of Mrs. Adrian, near the Veronica Spring; sent by A. H. Hastie, through Bach, Meese & Co., of San Francisco. The sample is clear, slightly alkaline in character, and with an earthy taste and odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	307.24	52.60
Soluble in water after evaporation	134.58	23.04
Insoluble in water after evaporation	102.57	17.56
Organic matter and chemically combined water	70.09	12.00
The soluble part consists of—		
Sodium sulphate (Glauber's salt)	25.31	4.33
Potassium sulphate, small amount		
Magnesium sulphate (Epsom salts), small amount		
Sodium chlorid (common salt)	104.32	17.86
Sodium carbonate (sal soda)	4.95	.85
The insoluble part consists of—		
Calcium and magnesium carbonates	101.17	17.32
Calcium sulphate (gypsum), chiefly		
Silica	1.40	.24

The amount of mineral salts in this water is by far too great to render its use admissible either for domestic or irrigation purposes. It differs very widely from the Veronica Spring water, whose analysis is given on page 61 of Report of Experiment Stations for 1890–91; the latter has more than seven times the amount of residue, and a very large proportion of Epsom salt, while this has but little of the latter.

Water sent by Philip H. Rice, of Santa Barbara. It contains nearly 41 grains of mineral matter per gallon, being quite double of what is usually found in irrigation waters. Over one half of this amount, however, consists of earthy matters, either unobjectionable or beneficial—lime, magnesia, and silica—that constitute soils. This can be done away with by using the "lime process" of softening hard waters. The rest of the mineral contents—say about 18 grains per gallon—consists of "white alkali" salts, viz., common and Glauber's salts. There is gypsum enough in the water to keep this alkali from becoming "black" under any ordinary conditions. On porous soils the water can probably be safely used for irrigation purposes.

Well water from T. M. Michaels, Palmdale, Los Angeles County.

"This town is situated on the line of the S. P. R. R., just at the foot of the mountains, on the north side of the Sierra Madre range. One mile south of us, just on the edge of the moutains, there is an upheaval of impervious clay—on a very straight line, varying very little from east to west—and is said to extend several hundred miles. This formation makes a natural dam at the foot of the mountains, over which drainage flows at various points, while at others the wet lands are formed. All along the upper side of this line water is close to the surface, while invariably only a few feet distant, on the opposite side of this

clay bed, water cannot be obtained until a great depth is reached. Realizing the probable importance of this formation in a supply of water, I sank a well on the upper side of this clay bed, and at 80 feet obtained a flowing stream. Is the water suitable for domestic supply and irrigation? If so, other flowing wells can probably be obtained."

The sample was clear, and without taste or odor. Reaction slightly alkaline.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	112.73	19.30
Soluble in water after evaporation		
Insoluble in water after evaporation		
Organic matter and chemically combined water	15.48	2.65
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	44.86	7.68
Sodium chlorid (common salt)	13.64	2.33
Sodium carbonate (sal soda)	2.48	.43
The insoluble part consists of		
Calcium and magnesium carbonates	35.22	6.03
Calcium sulphate (gypsum)		
Silica	1.05	.18

A further analysis showed traces of free ammonia, 0.032 parts per million of albuminoid ammonia, and 0.48 of oxygen consumed.

It is extremely unfortunate for the good of that region that this water, whose supply seems so abundant, should be so totally unfit for domestic use. Though free from any organic contamination, its mineral salts, especially the sulphates of potash and soda, are in too great quantity, and would, if taken constantly, exert a very weakening, laxative effect upon the system. For irrigation upon the sandy lands of that region the water might be used, provided easy drainage facilities were afforded. The accumulation of the salts in the soil would otherwise be rapid and disastrous.

Well waters from the dairy ranch of W. W. Orr, 3 miles from Downey, Los Angeles County; sent by Q. J. Rowley, M.D,

"There have been severe cases of typhoid fever in the neighborhood, and this water is suspected as the cause. The well is 78 feet deep, and has a double iron pipe lining it and supposed to be proof against surface water. The water is raised by a windmill and delivered into a wooden tank, whence it passes through another galvanized iron pipe into a second wooden tank, from which it is piped into the house and grounds. Sample No. 1 was taken directly from the well as delivered by the pump; No. 2 comes from the faucet in the kitchen."

Both samples were clear and without taste or odor.

	From Well.		From Faucet.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	28.27	4.84	28.56	4.90
Soluble in water after evaporation	10.57	2.81	10.34	1.78
Insoluble in water after evaporation	15.25	2.61	15.54	2.66
Organic matter and chemically combined water	2.45	.42	2.68	.46
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	8.03	1.37	7.80	1.34
Sodium chlorid (common salt)	.68	.12	.68	.12
Sodium carbonate (sal soda)	1.86	.32	1.86	.32
The insoluble part consists of—				
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	13.15	2.25	13.26	2.27
Silica	2.10	.36	2.28	.39

Sanitary Analysis.

	Grains per Gallon.		Parts per Million.		
	Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
No. 1. Direct from well	28.27	.42	.20	.054	1.04
No. 2. Kitchen faucet	28.56	.42	Trace.	.056	1.08

The prevalence of typhoid fever cannot be attributed to the water, for in both well and tank there is freedom from hurtful contamination.

In mineral salts, also, the amount is not sufficient for injury to the system, especially as so great a proportion consists of earthy carbonates.

Well water from within city limits of Los Angeles. The well is said to be about 400 feet above the center of the city, distant about 2½ miles. Sample sent by L. N. Peck.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	14.02	2.40
Soluble in water after evaporation	4.96	.85
Insoluble in water after evaporation	8.01	1.37
Organic matter and chemically combined water	1.05	.18
The soluble part consists of—		
Sodium and potassium sulphate (Glauber's salt, etc.)	1.00	.18
Sodium chlorid (common salt)	2.72	.46
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates, Calcium sulphate (gypsum)	3.34	.57
Silica	4.67	.80

This is a very good water for all domestic uses, both as to the quality and the quantity of its mineral contents.

Water from Los Angeles; sent by Professor Bunnell. The sample is slightly alkaline, but clear and without taste or odor.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	29.91	5.12
Soluble in water after evaporation	9.99	1.71
Insoluble in water after evaporation	12.45	2.13
Organic matter and chemically combined water	7.47	1.28
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	6.20	1.06
Sodium chlorid (common salt)	.95	.17
Sodium carbonate (sal soda)	2.84	.48
The insoluble part consists of—		
Calcium and magnesium carbonates	7.89	1.35
Calcium sulphate (gypsum)		
Silica	4.56	.78

A further examination showed the presence of the following, in parts per million: free ammonia, 0.05; albuminoid ammonia, 0.076; oxygen consumed, 1.04.

The water is quite free from hurtful organic matters, and although the mineral salts are rather large in amount, yet it could be used for domestic purposes. For irrigation the water is also suitable, save on heavy, ill-drained lands.

Waters from Mission Valley of the San Diego River, 8 miles from the ocean, San Diego County; sent by J. W. Clemens, of San Diego.

Sample No. 1 is from a well, near the dwelling, on a bench of land 30 feet above the level of the alluvial valley. The well is about 35 feet deep and the water rises in a coarse gravel. No. 2 is from a well in the flat, only about 8 feet deep. It has not been used for some time. No. 3 is from the supply pipe in the flat leading from a reservoir supplied by a pump in a well near the river bed.

The samples were all clear and without odor. No. 1 was sweetish to the taste, and Nos. 2 and 3 slightly yellowish in color. Nos. 1 and 2 were slightly alkaline in character.

	No. 1.		No. 2.		No. 3.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	57.94	9.92	30.61	5.24	28.85	4.94
Soluble in water after evaporation	33.88	5.80	16.59	2.84	14.60	2.50
Insoluble in water after evaporation	14.01	2.40	7.78	1.16	9.34	1.60
Organic mater and chemically combined water	10.05	1.72	7.24	1.24	4.91	.84
The soluble part consists of—						
Sodium and potassium sulphates (Glauber's salt, etc.)	6.11	1.06	3.96	.67	11.31	1.84
Sodium chlorid (common salt)	24.55	4.19	2.73	.47	2.05	.45
Sodium carbonate (sal soda)	3.22	.55	9.90	1.70	1.24	.21
The insoluble part consists of—						
Calcium and magnesium carbonates	13.43	2.30	6.55	1.12	8.53	1.46
Calcium sulphate (gypsum)						
Silica	.58	.10	.23	.04	.81	.14

The water of No. 1 is too highly charged with mineral matters to be safely used for any domestic purpose. That of No. 2 might do for

domestic purposes, but the large amount of carbonate of soda condemns it at once for irrigation. The water of No. 3 contains rather a large amount of the laxative salts, which might affect weak stomachs; but it might be safely used for irrigation on light, well-drained soils.

Well water from San Diego; sent by Mr. A. D. Haight. Analyzed by W. L. Dunn, of Oakland, a student in Agricultural Laboratory. Water clear, colorless, with salty taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	502.56	86.04
Soluble in water after evaporation	332.36	56.90
Insoluble in water after evaporation	66.99	11.47
Organic matter and chemically combined water	103.21	17.67
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	54.37	9.41
Sodium chlorid (common salt)	275.52	47.07
Sodium carbonate (sal soda)	2.47	.42
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	60.92	10.43
Calcium sulphate (gypsum)		
Silica	6.07	1.04

The analysis shows that nearly half of the solid matter is common salt, with a small proportion of Glauber's salt. It is essentially a brine, promising no medicinal qualities beyond those of sea water.

Well water from Encinitas, San Diego County; sent by Chas. R. Woodward.

"The well is situated on the mesa, about 40 feet above and one fourth of a mile back from high-water mark. The water was first struck at 70 feet, in a sandy formation, after passing through about 25 feet of a blue rock. The water rises to within 35 feet of the top of the well, and there seems to be a large supply. It is slightly tepid, but perfectly clear when first drawn; but after standing in the open air for a short time becomes cloudy and a metallic-looking scum rises to the top."

The sample sent was clear, colorless, and had a saline taste. The residue from evaporation did not blacken on ignition.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	396.96	67.96
Soluble in water after evaporation	294.46	50.41
Insoluble in water after evaporation	74.06	12.68
Organic matter and chemically combined water	28.44	4.87
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	268.98	46.06
Sodium chlorid (common salt)	23.25	3.97
Sodium carbonate (sal soda)	2.23	.38
The insoluble part consists of—		
Calcium and magnesium carbonates, etc.	74.06	12.68
Calcium sulphate (gypsum), chiefly		
Silica		

The water is too strongly charged with salts for any domestic use, or for the supply of cattle; it would weaken them generally. It is also too strong for any use in irrigation, as it would soon convert the land into "alkali" soils of the "white" class.

Well waters from National City, San Diego County; sent by G. F. Hargis. Well No. 1 is 53 feet deep, and its water is found in a bed of bowlders. Well No. 2 is 47 feet deep, with water in sand. The samples from both wells were clear and without taste or odor.

	Well No. 1.		Well No. 2.	
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	84.28	14.43	101.05	17.30
Soluble in water after evaporation	59.58	10.20	72.08	12.34
Insoluble in water after evaporation	19.74	3.38	17.87	3.06
Organic matter and chemically combined water	4.96	.85	11.10	1.90
The soluble part consists of—				
Sodium and potassium sulphates (Glauber's salt, etc.)	58.34	9.99	70.48	12.06
Sodium chlorid (common salt)				
Sodium carbonate (sal soda)	1.24	.21	1.60	.28
The insoluble part consists of—				
Calcium and magnesium carbonates	17.23	2.95	12.03	2.06
Calcium sulphate (gypsum)				
Silica	2.51	.43	5.84	1.00

The waters are too high in mineral salts to be fit for domestic purposes. They might do for irrigation on sandy, well-drained soils, where the mineral salts could not accumulate, but are entirely unfit for heavy clay lands.

Water of the Rio Grande, sent by Messrs. Ketelsen & Degetau, of El Paso, Texas. The sample was turbid and fetid, with a brownish flocculent sediment. Its contents per gallon are as follows:

Total residue	34.4 grains.
Insoluble after evaporation	3.5 grains.
Soluble after evaporation	30.9 grains.
The soluble portion contains:	
Common salt	22.6 grains.
Glauber's salt	1.2 grains.
Organic matter	7.1 grains.

This analysis agrees with those since made at the New Mexico Station, showing that both the soils and irrigation waters are nearly if not quite free from carbonate of soda, which together with the porous nature of the soils renders their use for irrigation perfectly admissible.

D. ARTESIAN WATERS.

Artesian water from a well eight miles southwest of Mendota, Fresno County; sent by Philip Dengler. The well is 480 feet deep. The sample was clear, but with a slight taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	74.07	12.68
Soluble in water after evaporation	64.02	10.96
Insoluble in water after evaporation	7.53	1.29
Organic matter and chemically combined water	2.52	.43
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.; some Epsom salts)	57.23	9.82
Sodium chlorid (common salt)	2.46	.42
Sodium carbonate (sal soda)	4.33	.72
The insoluble part consists of—		
Calcium and magnesium carbonates	3.62	.62
Calcium sulphate (gypsum)		
Silica	3.91	.67

The total of mineral salts in this water is too great to make its domestic use permissible, especially when so large a part consists of laxative Glauber's and Epsom salts. For irrigation purposes, also, this water could serve only in light and well-drained soils.

Artesian water from the S. P. R. R. round-house, Mendota, Fresno County; sent by J. H. Harding. Depth of well, 680 feet. The sample is clear, with taste and odor of sulphuretted hydrogen.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	75.23	12.88
Soluble in water after evaporation	63.43	10.86
Insoluble in water after evaporation	8.00	1.37
Organic matter and chemically combined water	3.80	.65
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc., some Epsom salt)	54.51	9.34
Sodium chlorid (common salt)	2.73	.46
Sodium carbonate (sal soda)	6.19	1.06
The insoluble part consists of—		
Calcium and magnesium carbonates	3.33	.57
Calcium sulphate (gypsum)		
Silica	4.67	.80

This water is very similar to that from the well of Philip Dengler, 8 miles from Mendota. Its mineral salts are too abundant (especially the Glauber's and Epsom salts) for domestic uses, while its carbonate of soda would doubtless cause a severe case of "black alkali" in the land irrigated with it, unless proper precautions were taken.

Water from a flowing artesian well, at Midway, Alameda County; sent by Wm. B. Faulkner. The sample was clear and without odor or taste.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	72.78	12.46
Soluble in water after evaporation	51.99	8.90
Insoluble in water after evaporation	14.01	2.40
Organic matter and chemically combined water	6.78	1.16
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	9.30	1.60
Sodium chlorid (common salt)	26.60	4.54
Sodium carbonate (sal soda)	16.09	2.76
The insoluble part consists of		
Calcium and magnesium carbonates	13.72	2.35
Calcium sulphate (gypsum)		
Silica	.29	.05

The large amount of mineral salts in this water makes it unfit for domestic, or for irrigation purposes on other but light, well-drained land.

Well waters from three artesian wells in Nordhoff, Ventura County; sent by E. F. Baker, of Nordhoff.

Wells Nos. 1 and 2 are only 175 feet apart. The depth of the former is 98 feet, of the latter, 204 feet. The water of the first flows at the surface 11½ gallons per minute, and would rise to the height of 19 feet above the surface of the ground. The water of No. 2 flows 16 gallons per minute, and would rise 35 feet above the surface of the ground. Well No. 3 is 113 feet deep, flows 15 gallons per minute, and is about 300 yards from the other two. The following strata were passed through in sinking Nos. 1 and 2:

Well No. 1.

Black adobe	2 feet.
Red soil	23 feet.
Blue clay	31 feet.
Sand	3 feet.
Sand and fine gravel	6 feet.
Sand and gravel	2 feet.
(At this depth, first flow of water, 10 gallons per minute.)	
Clay	6 feet.
Sand and fine gravel	3 feet.
(At this depth, second flow of water, 10 gallons per minute.)	
Yellow clay	14 feet.
Sand and clay	6 feet.
Sand and fine gravel	2 feet.
(At this depth, third flow of water, 11½ gallons per minute.)	

Well No. 2.

Black adobe	2 feet.
Red soil	20 feet.
Blue clay, with some gravel	24 feet.
(Water, 8 gallons per minute.)	
Blue clay	8 feet.
Sand	2 feet.
Gray and blue clay	13 feet.
Sand and fine gravel	3 feet.
Gray clay	3 feet.
Sand and fine gravel	2 feet.
Red clay	15 feet.
Sand and fine gravel	3 feet.
Red clay	10 feet.
Blue clay	3 feet.
Sand and fine gravel	1 foot.
Blue clay	20 feet.
Sand	6 feet.
Blue clay	49 feet.
Sandy clay	9 feet.
Yellow clay	4 feet.
Sand and gravel	7 feet.
(Water, 11½ gallons per minute.)	

Sanitary Analyses.

	Grains per Gallon.		Parts per Million.		
	Total Solids.	Chlorine.	Free Ammonia.	Albuminoid Ammonia.	Oxygen Consumed.
Well No. 1	23.36	.17	.01	.05	.70
Well No. 2	25.70	.42	.05	.05	.90
Well No. 3	22.55	.13	.01	.03	.65

The character of the mineral salts in these waters was not ascertained, but as the entire amount of total solids in each is within the limits of good potable waters, it is not probable that laxative salts exist to any serious extent. The waters are not contaminated to any extent with organic matters, a result to be anticipated in all deep wells whose water is delivered at the surface through pipes.

Artesian well water from Helena Orchards, Fullerton, Orange County. Sent by L. B. Benchley.

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	51.69	8.85
Soluble in water after evaporation	23.96	4.10
Insoluble in water after evaporation	20.73	3.55
Organic matter and chemically combined water	7.01	1.20
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	18.99	3.25
Sodium chlorid (common salt)	2.73	.47
Sodium carbonate (sal soda)	2.23	.38
The insoluble part consists of—		
Calcium and magnesium carbonates, chiefly	18.22	3.12
Calcium sulphate (gypsum)		
Silica	2.51	.43

Residue blackens on heating. The water contains some "white alkali," but can be used without detriment on light porous soil, from which the alkali can be washed out from time to time by flooding. If the soil is not already alkaline, it will take many years to cause injury from this water.

Artesian water from well in Buena Park, Orange County; sent by J. Whitaker. The sample was clear and without taste or odor. The composition is as follows:

	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	25.35	4.34
Soluble in water after evaporation	10.22	1.75
Insoluble in water after evaporation	10.22	1.75
Organic matter and chemically combined water	4.91	.84
The soluble part consists of—		
Sodium and potassium sulphates (Glauber's salt, etc.)	8.30	1.42
Sodium chlorid (common salt)	.68	.12
Sodium carbonate (sal soda)	1.24	.21
The insoluble part consists of—		
Calcium and magnesium carbonates	9.29	1.59
Calcium sulphate (gypsum)		
Silica	.93	.16

The amount of mineral salts present brings this water within the limits suitable for use, both domestic and irrigation.

Artesian Waters from Indio, a station of the S. P. R. R., on the border of the Colorado Desert, San Diego County; sent by M. L. Requa, of Oakland. The samples were all clear, tasteless, and odorless.

	New Well.				Reservoir at Spur.		Little Well at Spur.		Wise Well.	
	From Surface.		From Bottom.							
	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.	Grains per Gallon.	Parts in 10,000.
Total residue by evaporation	10.51	1.80	10.40	1.78	8.76	1.50	9.34	1.60	14.95	2.56
Soluble in water after evaporation	3.86	.66	3.86	.66	6.72	1.15	6.31	1.08	5.37	.92
Insoluble in water after evaporation	6.42	1.10	6.31	1.08	1.22	.21	2.33	.40	5.72	.98
Organic matter and chemically combined water	.23	.04	.23	.04	.82	.14	.70	.12	3.86	.66
The soluble part consists of—										
Sodium and potassium sulphates (Glauber's salt, etc.)	2.48	.43	2.48	.43	2.90	.49	3.69	.63	2.20	.38
Sodium chlorid (common salt)	.14	.02	.14	.02	.11	.02	.14	.02	.07	.01
Sodium carbonate (sal soda)	1.24	.21	1.24	.21	3.71	.64	2.48	.43	3.10	.53
The insoluble part consists of—										
Calcium and magnesium carbonates	4.09	.70	3.98	.68	.64	.11	1.75	.30	4.55	.78
Calcium sulphate (gypsum)										
Silica	2.33	.40	2.33	.40	.58	.10	.58	.10	1.17	.20

The waters bear a close resemblance to each other, both in purity and in the proportion of each mineral salt, thus indicating a common source, in the mountains bordering the desert. The waters are suitable for all domestic and irrigation purposes, and considering the region of occurrence, are remarkable for the small proportion of saline ingredients.

THE CIENEGAS OF SOUTHERN CALIFORNIA.*

By E. W. HILGARD.

A *cienega*, in the parlance of the native Californian, is a limited area showing a growth of water-loving plants, appearing sporadically in otherwise arid surroundings—usually hillsides or valley margins—and occasionally giving rise to flowing springs. The economic importance lately attained by these cienegas as sources of irrigation water by the aid of artesian borings, and some peculiarities of structure upon which their occurrence in that particular region depends, seems to justify at least a brief presentation of the facts in this report.

San Antonio Creek Cienegas.—A simple and typical case in point is presented, for instance, by San Antonio Creek, a stream issuing from a cañon in the Sierra Madre Mountains, near the town of Pomona, in the San Bernardino Valley, Los Angeles County. It is near the present divide between the adjacent drainage basins of the San Gabriel River on the west and the Santa Ana River on the east. Though a small stream, carrying only from 700 to 800 miner's inches of water in summer time, it has formed in front of its exit from the cañon a debris-cone or "fan," having a radius of 7 or 8 miles, of which the apex, near the cañon mouth, is between 400 or 500 feet above its base. On the slopes of this fan, as well as near its base, there appear numerous cienegas, some less than an acre in area, while others range up to twenty acres and over. In some of these, large sycamore trees are the only unusual indication amid the "bee pastures" of white sage, cactus, and other plants characteristic of the dry mesas of the south. In others, there is added the willow and clumps of "tule" (cat-tail) and other swamp plants. From some, springs issue naturally; in all, shallow dug wells find water; in many of them, artesian bores have been made with good success. The deposits penetrated in these bores are, of course, such as may be expected in a debris-fan; but they vary so quickly and completely in wells only a short distance apart as to show that the ancient portions of the fan have been formed under a régime exactly like the present—namely, an alternation of very coarse deposits of gravel and large cobbles, such as are now carried by the stream during the torrential floods to which the high ranges are subject, with fine silt and even clay, which are practically impervious to water. The abrupt diminution of velocity on emergence from the cañon results in the quick accumulation of cobble ridges or "kames," which sometimes change the main channel within a few hours to a totally different direction. It is obvious that in past times such changes of channel have thrown the water of the creek from one drainage basin to the other; at present it discharges toward the Santa Ana basin, but unless artificially prevented, there is no reason why it may not some time revert to the San Gabriel watershed. If we imagine the structure that must result from such a mode of accumulation of a debris-fan, the sporadic appearance and peculiar localization of the cienegas (being the points at which the water fed into the cone at the mouth of the cañon is forced near to the surface either by a cross ridge or by the termination of a water-bearing cobble-bed, underlain by an impervious layer) are easy to understand. But it is also obvious that the continued supply of water from the stream into the various old

*Read at the meeting of the Geological Society of America at Washington, August, 1891.

channels of the debris-cone must depend upon the maintenance of the open gravel surface at the apex of the cone. When this is wholly or partially closed, whether by natural or artificial processes, then, the source of supply being stopped, the springs or artesian wells dependent upon it must diminish or cease to flow. Such variations and stoppages have already been experienced at several points, and as they may prove very costly, if not disastrous, to heavy investments already made, it is quite important that the need of keeping the area of infiltration open for the winter floods should be fully understood by the populations concerned. When this is attended to, it is obvious that we have here natural storage reservoirs for flood waters, annually replenished and likely to be fully refilled each season, no matter how heavy may have been the drafts made upon them during the preceding irrigation season.

Santa Ana and Mill Creek Cienegas.—The most extensive example of debris-fan storage of flood waters thus far known to me occurs in the upper San Bernardino Valley, at the head of which two large streams—the Santa Ana River and Mill Creek—emerge from narrow cañons, at whose outlets there are truly phenomenal accumulations of huge bowlders, which in time of flood are tossed about by the torrents with a thundering noise, sometimes audible miles away. Here are many square miles of open cobble surface, into which flood waters can be and are absorbed with the greatest ease, although in the usual channels of the summer flow the bottom is made sensibly waterproof by finer sediments. Costly tunnels have been driven through these cobble-beds, under the impression that large amounts of water could be thus collected; but while the constant drip proves the perviousness and absorbent nature of the deposit, that very circumstance prevents the gathering-together of any very large supply of water in the relatively insignificant areas of the artificial drifts.

From the head of the debris-fan of Mill Creek to its base, near the town of San Bernardino, the distance is between 12 and 14 miles, according to the initial point chosen; the fall of the surface within the same distance is between 600 and 700 feet. The average width of the valley is about 10 miles, and artesian borings have shown the gravel and cobbles to be nearly a thousand feet in thickness within a mile of the southeastern edge. This enormous gravel mass, filled with water from the floods of the two streams, forms a natural reservoir of such magnitude that the drafts thus far made upon it by the numerous boreholes sunk in the lower valley have failed to show any such degree of mutual interdependence as is usually observed in wells situated short distances apart—a fact which I have ascertained by experimental measurements made under proper conditions. This relative independence of the flow of contiguous wells also indicates that the water-bearing stratum consists of gravel so large and so open that the water-mass may be considered as exerting its pressure rather freely in all directions; yet on reopening a closed well there always exists a material accumulation of pressure, which takes several hours to recede to its normal amount.

Besides the artificial outlets mentioned, however, there is a number of *natural* outlets on the slope of this great gravel reservoir. The most conspicuous is the source of Warm Creek, the stream which has been appropriated for the purpose of irrigating the well-known colony of Riverside. Warm Creek has no visible connection with any of the streams that descend from the Sierra Madre; it rises in the valley itself, fully 3 miles

away from the foot of the range. There is no obvious reason for its being there, but the water gathers from little rills and ditches within a space of about a quarter of a mile, acquiring within that distance nearly its full volume of from 2,000 to 2,500 inches during the dry season. At other points, also, "artesian" springs rise with considerable force and volume; and in the immediate flood-plain of the Santa Ana River, rivulets gather at many points on the margins, at the foot of the bluff some 7 or 8 feet above the river channel, and flow toward the latter to increase the volume of the stream. It thus happens that "the entire flow of the Santa Ana River" has been appropriated at at least three different points, each appropriator receiving a good flow; and that in the absence of any obvious important additions from incoming streams. As may be supposed, boreholes sunk in this region of spontaneous flows encounter at very small depths (from 120 to 150 feet) very copious flows of artesian water, in cobble-beds; while near the border of the valley not only is a greater depth required and the outflow less, but the materials penetrated are much finer.

Since the terraces of reddish loam that border the foot of the Sierra Madre from the head of the valley to the San Gabriel River indicate plainly that the subdivision of the valley into two drainage basins is a comparatively recent event, it does not seem improbable that the artesian reserve referred to might be tapped by deep borings much farther westward than has heretofore been attempted; perhaps within easy reach of the city of Los Angeles.

Temescal Valley Cienega.—A very striking exemplification of the origin of cienegas exists in the valley of Temescal Creek, one of the southern affluents of the Santa Ana River, in San Bernardino County. This creek is really the natural continuation of the San Jacinto River, of San Diego County; but an intervening lake basin (Lake Elsinore) prevents actual flow from the latter stream to the Temescal Valley, save in seasons of extraordinary rainfall. Its water is supplied almost entirely from the cañons of the Santa Ana Mountains, which have a rather copious rainfall in their higher portions. At the head of the valley there is a small lake (Lee's Lake) which, with no visible *in*flow, nevertheless has at its lower end a steady *out*flow of about 400 miner's inches of water during the dry season, thus forming part of the water supply of the South Riverside Colony. Examination shows that the lake is fed entirely by a series of springs, or rather an almost continuous ooze, from the enormous masses of granitic and other debris that have accumulated in front of the two uppermost cañons of the Temescal Valley, and which reach entirely across the valley to the foot of the (Temescal) range opposite. These debris masses are so porous that actual surface flow very rarely occurs, and no well-defined bed for a stream exists save where, close to the lake basin, the materials are relatively fine. Evidently the main body of the rainfall gathered into these cañons is stored in the coarser portions of the debris-fans above.

Below this lake basin the Temescal Valley is divided lengthwise by a series of low ridges formed of materials mostly impervious to water, of tertiary age. In front of the cañons of this lower portion of the valley similar great debris masses have accumulated, also; but since the impervious ridges mentioned prevent the outflow of water save during actual freshets (when small streams pass through gaps in the ridges), extensive cienegas have been formed between the valley ridges and the foot of the

Santa Ana range. In these, as in the upper San Bernardino Valley, "artesian" springs rise at many points, and vegetation remains bright green all summer. Borings thus far made have developed a very copious artesian flow of nearly 600 miner's inches, which can doubtless be materially increased; and this, with the flow from the lake above, constitutes the water supply for the colonies below.

Importance of Cienegas as Sources of Water Supply.—These examples, which could be greatly multiplied, show sufficiently both the nature and origin of the cienegas, and also their practical importance as sources of water supply, which calls for a more careful survey of their extent of occurrence than has heretofore been made. While they do not render the establishment of artificial storage reservoirs superfluous, they do supplement them locally to a very material extent, rendering it possible to occupy for agriculture large areas that otherwise would have remained arid for many years to come. But there arises the question as to the geographical limits within which these natural storage reservoirs may reasonably be sought, for it is notorious that they are not usually found, and the name and idea of the cienega is not generally known, in the northern portions of California.

The essential condition of cienega-formation is manifestly the opportunity for the abundant formation of deposits of exceptionally coarse and pervious gravel and cobbles near the points where the cañons emerge from the mountains. This, again, is necessarily conditioned upon the occasional occurrence of violent, torrential rainfall in the mountains, alternating with periods when quiet deposition allows of the formation of water-shedding layers. Another condition appears to be the ready weathering of the parent rocks into rounded forms, by which close packing is prevented, so that abundant interspaces are permanently maintained.

Both conditions are fulfilled to an unusual extent in the granitic ranges of Southern California. The rock is rather easily disintegrated, first into larger and then into smaller rounded masses, from which large quantities of very coarse angular sand have been detached, and which continue to disintegrate rapidly when exposed to the air, but are relatively stable when submerged in the debris mass, and so maintain porosity. Such granitic or granitoid material forms the main body of all the larger cienegas I have examined in Southern California; and the remarkably large proportion of potash contained in their waters in consequence is of no small economic importance.

It is therefore reasonable to presume, and it seems *a priori* probable, that a concurrence of the two conditions, climatic and petrographic, is requisite for the formation of cienegas upon a practically useful scale; and the extent to which this concurrence actually exists, geographically, is a question of no little practical interest.

IV. ANALYSES OF ROCKS, CLAYS, MARLS, ETC.

Marl and clay rock, from Wm. Bowring, San Dimas, Los Angeles County. The marl contains 22.9 per cent of carbonate of lime; and the clay rock, 0.50 per cent of phosphoric acid. While the latter is comparatively rich in phosphates, yet it is not sufficiently so to be of commercial value when transportation is expensive.

Limestone, from San Jacinto, San Diego County; sent by F. R. Haas.

	Per Cent.
Carbonate of lime	72.40
Silica	27.50
Phosphate of lime	.10
	100.00

This is but an ordinary limestone, with too much silica for the production of first-grade lime.

Calcareous rock, sent by Dr. H. Fine, of East Oakland, for the determination of phosphoric acid. It was found to contain nearly one half of 1 per cent (0.47), which is not sufficient to make the rock of any value as a source for that acid.

Cement from Mexico. Analysis was made at request of the College of Mechanics, University of California.

	Per Cent.
Lime	60.14
Silica (soluble in carbonate of soda)	21.33
Sand	1.53
Alumina	6.49
Ferric oxid	4.50
Magnesia	1.48
Potash	.80
Soda	.70
Sulphuric acid	1.02
Phosphoric acid	.14
Carbonic acid	1.12
Water	.17
	99.42

This is a very good cement, the lime and silica, as the basis, being in proper proportions. Its composition compares well with the best cements of the East and of France. It should be very durable, for it is claimed that any cement having less than 40 per cent of lime, magnesia, and alumina would soon yield to the weather, though hardening quickly.

Peat, two samples, from Mowry's Station, Alameda County; sent by Carnall-Hopkins Co., San Francisco. The air-dried substance contains:

	No. 1.	No. 2.
Water	17.44	17.85
Volatile matter	67.16	73.16
Ash	15.40	9.09
Totals	100.00	100.00
Phosphoric acid in ash	2.64	4.09
Phosphoric acid in peat	.41	.36
Sodium carbonate in ash	.30	3.65
Sodium carbonate in peat	.04	.31
Water in freshly-dug peat	39.98	78.41

Such peats usually contain about 2 to 3 per cent of nitrogen, which, however, cannot be counted upon as effective in fertilization. While thus the amount of fertilizing ingredients in the substance is not enough to entitle it to be used directly, by itself, it is an excellent material for composting, bedding of cattle, etc., as an absorbent. It is also of fair quality as a fuel.

Borate of lime, sent by C. C. Merrill, of Riverside. This, as determined by Mr. Palache of the Mineral Laboratory, is pandermite, an almost pure hydrated lime borate. The locality in which it was found is not given.

Brine, from Antelope Crystal Salt Works, Colusa County. It has the following composition, in grains per gallon:

Chlorid of sodium (common salt)	1,297.31
Chlorid of magnesium	332.36
Chlorid of calcium	2,191.59
Sulphate of lime	56.66
Sulphate of magnesia	Trace.
Silica	Trace.

Specimens Sent for Examination or Identification.

Magnetic iron ore.....by J. A. Clark, of Bakersfield, Kern County.
Quartz.....by Mrs. Rodgriss, of Mountain View, Santa Clara County.
Iron pyrites.....by Mrs. Rodgriss, of Mountain View, Santa Clara County.
Selenite.....by F. A. Connelly, of Bishop, Inyo County.
Infusorial earth.....by F. A. Connelly, of Bishop, Inyo County.
Micaceous soil.....by F. A. Connelly, of Bishop, Inyo County.
Talcose rocks (3 specimens).....by J. S. Hilton, of Porterville.
Pyritous rocks.....by R. Stevens, of Sisson.
Volcanic glass.....by Chamber of Commerce, Los Angeles.
Gypsum.....by William Owen, of Santa Barbara.
Volcanic ash.....by E. Roebuck, of Gila Bend.
Calcite.....by J. A. Lytle, of Tulare.
Volcanic ash.....by J. H. Beaulien, of South Riverside.
Quartz.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Tourmaline crystal.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Actinolite.....by Mrs. Fannie Goodman, of Outing, Riverside County.
Pyritous quartz.....by John Eslick, of Eureka.
Talc.....by N. E. Beckwith, of Los Gatos, Santa Clara County.
Steatite, of San Jacinto Mountains.....by H. F. Whalen, of Riverside.
Calc spar.....by Charles A. Raber, of San Bernardino.
Limestone.....by Charles A. Raber, of San Bernardino.
Hematite.....by Charles A. Raber, of San Bernardino.
Jaspery quartz.....by Charles A. Raber, of San Bernardino.
Galena.....by D. W. Osborne, of Winchester.
Greenstone.....by Thomas Dickenson, of Yager, Humboldt County.
Quartz debris, cemented.....by Mrs. Clesham, of Jamul, San Diego County.
Greenstone.....by H. J. Wibel, of Riverside.
Calcite crystal.....by J. N. Ross, of Fresno.
Halloisite (clay).....by T. C. Willis, of Los Angeles.

Pyritous sand.....by John Winchester, of Cahto, Mendocino County.
Red ochre.....by John Winchester, of Cahto, Mendocino County.
Black rock—powder.....by John Winchester, of Cahto, Mendocino County.
Yellow ochre.....by John Winchester, of Cahto, Mendocino County.
Steatite.....by W. J. Richardson, of Letcher, Fresno County.
Volcanic ash.....by Addison Rucker, of Willits, Mendocino County.
Magnesian slate.....by Charles A. Raber, of Riverside.
Calcite.....by Rev. W. B. Cullen, of Glendora, Los Angeles County.
Black sand.....by W. J. Evans, of Ruby, Siskiyou County.
Copper ore.....by E. J. Langlos, of Moro, San Luis Obispo County.
Kaolinite.....by Andrew Martin, of Carpenteria, Santa Barbara County.
Clay.....by William Boving, of San Dimas, Los Angeles County.
Clay.....by Chaffee & Bonestel, of Ventura.
Clays (8 specimens).....by — Stevens, of Ione, Amador County.
Clay.....by J. T. Dempsey, of Smartsville, Yuba County.
Clays (2 specimens).....by A. G. Platt, of Rancho del Valle, Alameda County.
Asphaltic clay.....by F. Hartmann, of San Buenaventura, Ventura County.
Clay.....by C. F. Harkrader, of Arbuckle, Colusa County.
Chalk.....by West Side Fruit Growers' Association, Santa Clara.
Shell marl.....by E. Hornbeck, of Stuart, Santa Barbara County.
Lime carbonate.....by G. F. Foster, of Antioch, Contra Costa County.
Marl (2 specimens).....by K. H. Dorsey, of Spadra.
Shell marl.....by M. T. Clark, near Del Mar, San Diego County.
Calcareous marl.....by J. W. Reese, of Fresno.
Yellow ochre.....by J. W. Crittenden, of South Riverside.
Infusorial earth.....by J. A. Mathis, of Santa Barbara.
Sandstone.....by J. A. Mathis, of Santa Barbara.
Black sand.....by Horace Metcalf, of Point Loma, San Diego County.
Bone meal.....by J. Footell, of Florin.
Cotton-seed meal.....by — McLaren, of San Francisco.
Glauber's and common salts.....by Dr. E. Aiken, of Los Angeles.
Bone meal.....by H. E. Phelps, of Ontario.
Peat.....by J. P. Raymond, of Black Diamond, Contra Costa County.
Egg albumen.....by — Beringer, of St. Helena.
Glauber's salt.....by Harry W. McCray, of Bakersfield.

V. FERTILIZERS AND GYPSUM.

Commercial fertilizer,. sent by Edward Berwick of Monterey. The sample as received has the following composition:

Nitrogen—		
As ammonia ready formed	.28	
As nitrates	1.90	
Organic	13.15	
Total		15.33
Calculated as ammonia	18.61	
Phosphoric acid—		
Soluble in water	.07	
Reverted	7.22	
Available	7.29	
Insoluble	14.48	
Total		21.77
Potash		.51

Natural fertilizers (4 samples), from F. W. Fowler, South Riverside. No. 1 has a crystalline appearance; gypsum flakes well marked. No. 2, in the form of a white powder. No. 3, a greenish-gray earth lump, coated and streaked with salt. No. 4, a coarse white powder.

	No. 1.	No. 2.	No. 3.	No. 4.
Silica	1.07	9.09	28.18	19.08
Sulphate of lime (gypsum)	31.61	55.15	3.54	11.53
Carbonate of lime	67.32	45.76	35.64	11.63
Phosphate of lime			1.96	2.53
Chlorid of calcium			1.60	
Chlorid of sodium			28.09	.96
Carbonate of soda			.99	1.19
Sulphate of soda				53.28
Total	100.00	100.00	100.00	100.00

The first and second samples contain fair amounts of gypsum, but only for local use; not rich enough to make them of commercial value. The third sample is made up chiefly of lime carbonate and common salt, while the last is composed chiefly of Glauber's salt (sulphate of soda), with some gypsum and lime carbonate.

Fertilizer, from Dwight L. Wilbur, of Riverside.

Moisture		14.64
Nitrogen—		
As ammonia	.70	
Organic ammonia	6.81	
Total as ammonia		7.51
As nitrates	None.	
Phosphoric acid—		
Water-soluble	.69	
Reverted	4.43	
Total available	5.12	
Insoluble	4.60	
Total		9.72
Potash		.07

Guano fertilizer, from J. W. Kishler, of Riverside. Analysis made by P. W. Tompkins, of San Francisco, student in Agricultural Laboratory.

Moisture		18.55
Nitrogen—		
As ammonia	5.77	
Organic ammonia	3.15	
Total as ammonia		8.92
As nitrates		Trace.
Phosphoric acid—		
Water-soluble	6.87	
Reverted	6.37	
Total available	13.24	
Insoluble	1.75	
Total		14.99
Potash		3.26

Bone dust, from Calcutta, India; sent by Parrot & Co., of San Francisco.

	No. 1.	No. 2.
Phosphoric acid	24.86	27.75

The average percentage of phosphoric acid is about 30 in pure bone-meal, and hence the above samples are somewhat below the purity mark. No. 2, however, may be regarded as very good and worthy of importation.

Gypsum, from John H. Gray, of San Francisco. A white translucent piece, very pure, quite free from carbonate of lime. It was sent by the Central Milling Company, of Hollister, and said to be found in Bitter-water Valley, San Benito County.

Gypsum, sent by Mr. R. Rickard, of Berkeley.

	Per Cent.
Gypsum	95.63
Carbonate of lime	2.03
Sand, etc.	2.34
	100.00

This is a very good specimen of gypsum, of a high degree of purity.

Another specimen, a white powder, was found to contain 95 per cent of gypsum.

Gypsum, from Herman Mier, of Sacramento. The samples comprise: No. 1, a white granular gypsum, very pure, though having some carbonate of lime; No. 2, a selenite crystal; and No. 3, a nodule of limestone in concentric layers. No. 1 is the most valuable, and is said to occur in large quantity at Coalinga, Fresno County.

Gypsum, from Herman Mier, of Sacramento; analyzed by J. W. Mills, of Marysville, a student in Agricultural Laboratory.

	Per Cent.
Gypsum	89.94
Carbonate of lime	3.16
Iron and alumina	Traces.
Sand, etc.	3.00
Moisture and loss	3.90
Total	100.00

This is a very good gypsum, and nearly as pure as can be obtained in the market. Commercial samples sometimes reach a purity of 95 per cent, but are more generally below that.

Gypsum, from San Benito County; sent by E. S. Jones, of San José, Santa Clara County; analyzed by P. W. Tompkins. No. 1 is a massive variety of very pure gypsum; Nos. 2, 3, and 4 are whitish gypseous powders, No. 3 being the most impure. The composition of Nos. 2 and 4 is as follows:

	No. 2.	No. 4.
Gypsum	79.48	83.88
Sand, silica, etc.	8.06	9.67
Carbonate of lime (6 to 8 per cent)	12.46	4.00
Other impurities		2.45
	100.00	100.00

The above samples of gypsum are quite within the limits of usual commercial qualities of "land-plaster," although of course the cost of transporting say 20 per cent of inert matter will prevent its shipment to long distances. For the latter purpose, the grinding of the hard rock (No. 1) which is always high in the ninety per cents, would be the proper thing; but the readiness with which the lower grade can be prepared for use may offset in the reduction of cost the difference in freights.

Gypsum, two samples; sent by Louis Bravermann, of San Francisco. An analysis gave the following composition:

	No. 1.	No. 2.
Gypsum	40.75	76.14
Sand	47.34	16.86
Other impurities	11.91	7.00
	100.00	100.00

The first sample of gypsum can be used by taking correspondingly larger quantity, but, of course, the price should be correspondingly lower than that of material double the purity.

The second, which is from near Mendota, is a very fair grade of gypsum, though not up to the standard of much that is in the market, and which contains as much as 90 per cent of gypsum.

Gypsum and *gypseous clays*, sent by A. C. Vandivier, of Firebaughs, Fresno County. They were taken from the foothills west of the valley. The result of the examination is as follows:

No. 1—Lead-colored clay, with 7.2 per cent of gypsum.
No. 2—Yellowish clay, with 4.0 per cent of gypsum.
No. 3—Deep purple clay, with 4.2 per cent of gypsum.
No. 4—Light gray clay, with very little gypsum.
No. 5—Light-colored sand, with 2.1 per cent of gypsum particles.
No. 6—Purple clay, with very little gypsum.
No. 7—Fragments of purple claystone.
No. 8—Massive purple claystone.
No. 9—Gypseous clay, with 29.4 per cent of gypsum.
No. 10—Whitish sandstone.

In No. 9 only is there sufficient gypsum to make its application to the land worthy of any expense, and then only very near the locality. Fully three times as much of this as of the good commercial article would have to be applied.

Gypseous marl, from J. W. Reese, of Fresno; analysis made by P. W. Tompkins.

	Per Cent.
Silica, sand, etc.	17.39
Gypsum	1.28
Carbonate of lime	81.33
	100.00

It also contains one tenth of one per cent of phosphoric acid. The sample cannot be called gypsum, but rather a slightly gypseous marl, and of no special value.

Gypsum and clays, sent by P. Dengler, of White's Bridge, Fresno County. One lot, from 12 miles west of Los Baños, comprised a sheet of impure gypsum about an inch in thickness; a sample of grayish clay, containing a little sulphate of magnesia; and a red, sandy earth holding much sulphate of magnesia and some carbonate of lime.

Another lot, from 20 miles north of the first, comprised large columnar crystals of gypsum; a light gray earth, with 4.2 per cent of gypsum; and a red ochreous earth from beneath the gypsum on the hillside. A white alkaline earth near the latter contained 23 per cent of sulphate of magnesia, and 0.8 per cent of gypsum.

Gypsum, from Coast Range foothills west of Tulare; sent by C. Lazenby, of Tulare, and E. D. Jones, of Dudley. The sample is quite pure, containing 94.2 of gypsum and 5.8 of insoluble matter. There are only traces of carbonate of lime. With good transportation facilities and an abundant supply of the mineral, it should be highly remunerative.

Gypsum, from John Roth, of Woodville, Tulare County. The specimen is from the west side of Tulare Lake. It is in the form of a light-colored hard rock, with much carbonate of lime. The percentage of gypsum is 86, which brings it into the class of profitably working deposits if in sufficient quantity and near transportation facilities.

Gypsum, from W. T. Hall, of Visalia; analyzed by Miss H. B. Perkins, of Alameda, a student in the Agricultural Laboratory. The sample is in the form of a powder, and has the following composition: Gypsum, 84.53 per cent; sand and other impurities, 11.98 per cent; moisture, 3.45 per cent. This is very fair gypsum, though not as rich as some found in the market, which run as high as 95 per cent. In application, 560 pounds of this must be used for every 500 pounds of the latter.

Gypsum, sent by Mrs. Nellie Boyd, of Fresno. It has the following composition:

Gypsum	40.73
Sand	47.34
Other impurities	11.91
	100.00

This is rather a low-grade article, and with 90 per cent gypsum selling at say $10 per ton, should be proportionately low in price.

Gypsum, from the Alpine Plaster Company, of Los Angeles. The sample is in the form of a creamy-white powder, and on analysis was found to be composed of 78.5 per cent of gypsum, 15.5 per cent of carbonate of lime, and 6 per cent of insoluble matter. The percentage of gypsum is rather low for a commercial article.

Gypsum, from Antelope Valley, Los Angeles County; sent by Geo. H. Delp, of Los Angeles. It is said to form an almost inexhaustible bed

near the railroad at Harold Station, same county. The sample is whitish, and contains a little carbonate of lime. The percentage of gypsum is a little more than 95 per cent, which makes it quite valuable.

Gypsum, from Fowler & Smith, of Los Angeles. Sample No. 1 is whitish, with hard lumps of the mineral. It contains only 36.8 per cent of gypsum, the rest being chiefly insoluble matter; it is therefore suitable for local use only. Sample No. 2 contains fragments of the hard country rock, which could be removed by sieve. The sample then contains 68 per cent of gypsum, 20 per cent of insoluble residue, and the rest of other acid-soluble substances not determined.

Gypsum, from Rev. W. B. Cullen, of Glendora, Los Angeles County. A solid piece, quite white and pure, found in a stratum three feet in thickness, in a water tunnel in the mountain.

Gypsum (two samples), from J. A. Whitaker, of Buena Park, Orange County. Sample No. 1 was analyzed by J. Koshland, of San Francisco; No. 2 by F. W. Roeding, of San Francisco, both students in the Agricultural Laboratory.

	No. 1.	No. 2.
Gypsum	68.19	38.85
Carbonate of lime	9.40	4.27
Iron and alumina	2.85	4.45
Sand, etc.	14.64	47.84
Moisture and loss	4.92	4.59
Totals	100.00	100.00

Of the above samples, No. 2 does not contain a sufficient amount of pure gypsum to warrant transportation, and is available only for local use.

Gypsum, sent by M. E. Mathes for the South Riverside Fertilizing Company. The sample was a grayish powder, having 55.35 per cent of pure gypsum and 33.14 of sand and other impurities. It is hardly of sufficient purity to warrant cost of long transportation, but can be used locally, in larger amounts per acre than if pure.

Gypsum, from Lawler & Smith, of Riverside. Samples sent are simply low-grade gypsums, which may do for neighborhood, but not for shipment to a distance, so long as there are commercial grades of 90 per cent and upward at command.

Gypsum, commercial sample, taken as an average of eight different sacks in the warehouse of the Paoli Gypsum Company at Mendota, and also samples from the deposit itself.

	Warehouse.	Deposit 1.	Deposit 2.
Gypsum	73.5	92.90	84.20
Sand and clay	19.5	7.10	15.80
Other impurities	7.0		
Totals	100.0	100.00	100.00

The impurities are in part doubtless due to the fact that the bulk of the gypsum was taken from the surface of the deposit, where sand and dust had been blown upon and imbedded in it. The samples taken

from the deposit itself prove to be high-grade gypsum, and with care on the part of the laborers the commercial article can be greatly improved.

Gypsum (four samples), sent by F. W. Fowler, of South Riverside. No. 1 is an impure gypsum; No. 2, a white powder; No. 3, a gray earth in lumps, coated, and streaked with salt; No. 4, a coarse gray powder. An analysis of each gave the following result:

	No. 1.	No. 2.	No. 3.	No. 4.
Calcium sulphate (gypsum)	31.61	55.15	3.54	11.33
Calcium and magnesium carbonates	67.32	45.76	35.64	11.63
Calcium chlorid			1.60	
Calcium phosphate			1.96	2.53
Sodium chlorid			28.09	.96
Sodium carbonate			.99	1.19
Sodium sulphate				53.28
Silica	1.07	9.09	28.18	19.08
Totals	100.00	100.00	100.00	100.00
Phosphoric acid			.89	1.15

Nos. 1 and 2 are not sufficiently gypseous to render them of any value except as a local application to soils. Nos. 3 and 4 are of no practical value as fertilizers, the phosphoric acid being in an insoluble condition.

Gypsum sent by the Alpine Plaster Company, of Los Angeles. A cream-colored, soft, earthy powder, found in the gypsum beds. Sent for identification. It resembles somewhat the loose surface material that covers the beds of gypsum near Lovelocks, Nevada, and like it, is also rich in gypsum, as shown by the following analysis:

	Per Cent.
Insoluble matter	0.5
Gypsum	94.4
Carbonate of lime	5.1
Total	100.0

PAOLI GYPSUM COMPANY'S MINES, LOCATED NEAR MENDOTA, FRESNO COUNTY, CAL.*

By E. W. Hilgard.

The great importance of an abundant and reasonably cheap supply of gypsum as a fertilizer is recognized everywhere. Although not universally efficacious, like the phosphates, its favorable effect on the legumes—peas, beans, and clovers, including alfalfa—is enough alone to give it a prominent place in agriculture. Its special importance in California is due to the fact (first announced from the State Experiment Station) that it is an effectual antidote to the "black alkali" that afflicts some portions of the State; where it impregnates the soil, not so much in large, continuous tracts as in spots, varying from a fraction of an acre to several acres, where little or nothing can be grown, and which mar the continuity of fields, vineyards, and orchards.

Experience shows, moreover, that as a rule such spots extend their area as irrigation is practiced, invading bearing plantations of all kinds and causing loss and discouragement. Yet the fact that such lands

* First published in "Fresno Republican."

when once reclaimed are profusely and lastingly productive, constitutes a strong incentive toward the utilization of the alkali lands, and renders the question of their reclamation for culture a very important one.

The characteristic ingredient of "black alkali" being carbonate of soda, it follows that when gypsum is applied to land impregnated with it, an exchange of chemical ingredients takes place, the sal soda being converted into Glauber's salt, or sulphate of soda, while the gypsum becomes carbonate of lime, or chalk. Glauber's salt, with more or less of common salt, constitutes the "white alkali," which is rarely abundant enough in the soils to form an obstacle to their cultivation, being many times less injurious to vegetation than the carbonate of soda.

But gypsum acts not only as a neutralizer of the injurious effect of the carbonate of soda on the plants themselves; it is also of essential benefit in that it renders friable, and therefore tillable, the hardpan always formed in "black alkali" lands; moreover, it serves to retain in the soil the humus and phosphates which the soda has dissolved, and which would be leached out of the land, to its great injury, if it were attempted to reclaim it by underdraining alone.

These good effects have been verified in practice many times over, outside of the successful experiments made at the Experiment Station near Tulare. But until now, gypsum (land-plaster) has been rather costly for general use, on account of the heavy cost for transportation from a distance to the points where it is mainly needed, viz.: in the upper San Joaquin Valley; nor has quality of the material furnished been always satisfactory.

It is thus a matter of no little interest that another mine has been found and partially developed, which combines a location near the chief consumers of land-plaster with an excellent quality of material easily mined and crushed for farmers' use. At the suggestion of John S. Dore, of Fresno, the writer has lately visited the new mine and believes the results of the examination to be of sufficient general interest for immediate publication.

This mine is located in the ridges bordering the west side of the Great Valley, just north of Tome Creek, and about five miles south of the Big Panoche. It was discovered in 1892 by J. H. Hall, of Selma, and is owned and worked by the Paoli Gypsum Company, of Selma and Mendota, Fresno County; the location being about 18 miles west-southwest from the latter station.

The main ridge, on which the gypsum appears at the highest level, extends about 3,000 feet along the creek, to which it falls off steeply. Toward the north there extend from this ridge four spurs, from one third of a mile to one mile long, on the crests of which the gypsum crops out abundantly, with a gentle dip toward the valley. The deposit on the crest of the main ridge, where most work has been done, shows a thickness of at least 30 feet, but its lower limit has not been exposed.

At the foot of the east slope of the third spur from the main summit, in a deep cañon and quite 150 feet vertically below the highest outcrop, there is a long exposure of a regular stratum about 18 feet thick so far as visible. Whether or not there exists a solid mass of the mineral from the outcrop to the summit, cannot be seen; should such be the case the mass would be enormous, but in any case the deposit is a very large one, sufficient to supply the needs of the San Joaquin Valley for a long time to come.

The samples collected, which of course are essentially "croppings," show the material to be very nearly uniform from top to bottom; a yellowish-white, chalky mass, easily crumbled and therefore readily put in shape for farmers' use. Eight samples were selected to represent the outcrops on the crests of the several ridges and also the one in the cañon mentioned above. The analyses of four of these gave the following results:

	Gypsum.	Sand Moisture and Carbonates.	
		Clay.	Lime, etc.
No. 1, from summit of main ridge	95.24	1.98	2.78
No. 5, from second spur, middle of crest	91.74	1.52	3.74
No. 6, from third spur, in cañon	92.90	2.60	4.50
No. 7, from fourth spur, near road	82.20	8.21	3.75

These results render superfluous the analysis of the other four samples taken. It is probable that had sample No. 7 been taken farther from the surface most of the sand it contained would not have been found, since the rest contain none like it. It is probable that the average of the whole deposit ranges above 90 per cent, since the only one of the samples taken in the mass itself (No. 1, from the main workings thus far done) is the highest of all, and, counting out the 2 per cent or thereabouts of atmospheric moisture, is probably equal in purity to any gypsum thus far found in quantity west of the Sierra Nevada. Selected portions of the deposits will undoubtedly be available for burning into plaster of Paris for builders' use.

It is thus obvious that whenever this mine shall be worked on a proper technical basis, the other mines supplying plaster will have to look to their laurels in competition with it. It is proper to suggest in this connection that gypsum, like all other fertilizers, should be sold on the basis of a guaranteed percentage of the pure substance, and not simply by weight or measure. We have repeatedly heard of what has been bought for gypsum failing to produce any effect on black alkali, and have traced the cause to material bought for land-plaster, which contained little or no gypsum. In this matter, as in the fertilizer trade generally, the need of State control and inspection, such as exists in the majority of the States of the Union, becomes more and more apparent.

The Experiment Station is compelled to decline any responsibility as regards the materials actually furnished the farmers by dealers or manufacturers, even though samples of what purports to be the same material may have been analyzed here and such analysis may be attached to the packages. While we have reason to believe that the fertilizers supplied by reputable houses in California are what they are represented to be, to a degree unusual in States not exercising supervision, yet the impositions that are occasionally practiced tend to discredit not only those directly responsible, but to damage the fertilizer trade at large, and to discourage the free use of the *bona fide* articles by farmers. This is a case in which even the anti-paternalism of Secretary Morton must yield to what has been proved to be the only practical solution of the question of "fertilizers true to name."

GYPSUM MINE IN SAN BENITO COUNTY.

Another important gypsum mine, of a character somewhat similar to the one just described, has been lately rediscovered in the Gabilan range, San Benito County, 10 miles east of Kings City, by Mr. E. S. Jones, of San José.

Specimens of the best portion of this deposit have been in the collection of the College of Agriculture for fifteen years past, but the finder disappeared without divulging the location. According to the best information obtainable the deposit lies with but a slight dip toward the Salinas Valley, in a series of ridges separated by ravines. Its upper portion consists of solid crystalline gypsum rock of gray tint and greatly resembling limestone, but much softer, yet still requiring an energetic crushing machine to reduce it. An analysis formerly made gave its purity at over 98 per cent. The thickness of this material is said to vary from 3 to 7 feet in various localities. This solid gypsum rock is underlaid by a large deposit of soft, marly material, containing from 40 to 60 per cent of gypsum, together with carbonate of lime, clay, and sand. This marl, while not suitable for transportation to a distance, could be very advantageously used for fertilization within easy hauling distances.

The ground gypsum rock has already been placed on the market at San José and elsewhere, and its use has been followed in many instances known to me by exceedingly favorable results, even outside of properly alkaline lands. It is to be hoped that before long it will be made more widely available to farmers.

CROPS AND FERTILIZERS, WITH REFERENCE TO CALIFORNIA SOILS AND PRACTICE.*

By E. W. Hilgard.

California has now become old enough to consider seriously the question of fertilization. It is true the lands of the State are exceedingly productive naturally; they are doubtless more so than most of those of the Eastern States, as our investigations have shown. And yet, the peculiar form which the agricultural interest has taken in California, that of horticulture, brings forward the question of fertilization in this State earlier than in other States of the same age. The reason is obvious. The investments made in orchards and vineyards are permanent; they are costly; they are to be maintained for a number of years. Unlike the annual crops which usually occupy the farmers in the States east and west of the Mississippi, or, more properly, between the Rockies and the Alleghanies, our plantings are expected to hold good for twenty, thirty, and even forty years; at least we hope so. And from this impracticability of change and rotation of crops comes the inconvenience of being obliged to make returns to the soil very much sooner than would otherwise be the case; for, as we all know, the continual cropping of land with one and the same crop is a very exhaustive process, and when the crops are annual and can be changed that is a very desirable course to pursue. One can, by continual cropping with the same crop,

* Read before the State Horticultural Society, May, 1892.

reduce the production of his land to the lowest limit of profitableness in one third or one fourth the time it would have lasted if a change of crops had taken place. The cause we will discuss presently. Now, in the East the custom has been that when the land gives out the party moves farther west. But we cannot do that very well, and if we spread out sideways we will soon come in contact with regions where other people have already settled, and we would hardly want to leave California anyway.

Maintenance of Profitable Production.—To maintain profitable production we must *replace what the crops take away;* therefore, the first thing needful is to know what the crops *do* take away. It makes a material difference whether you take the whole plant and analyze it and its ashes, or only the *portion usually harvested;* a very wide difference. If root, branch, leaves, and fruit are taken away altogether, there will be found on the whole a remarkable similarity between crops of different sorts. If we take the apple tree with apples, orange tree with oranges, and the wheat plant as a whole—root, straw, ears, and all—we would not find a very great difference; but in cropping we take very different *portions* of the plants grown. In the case of wheat we take seed only; in the case of orchard trees we take the fruit besides the seed; of root crops we take only the root, etc. This brings about very wide differences in the material that we extract from the soil in cultivating different crops.

Take, for instance, wheat, which has occupied and still occupies a very large space in our agriculture. It has been the custom in early times to sell the grain and burn the straw. Now, if the straw had been burned standing all over the field after heading, that would not have been so bad; but when the straw was burned in stacks, the heat generated was so great as to reduce most of the ashes to glass, such as you see in the ash-pit of straw-burning engines. To burn the straw, therefore, took away from the soil just as large a portion as though it had been sold.

In the Southern States, not long ago, I saw that lands which, when originally cultivated, gave four hundred pounds of cotton lint to the acre, were being cultivated still, and now produce no more than one hundred pounds to the acre. But the actual expense of production, aside from picking and ginning, is now just as great as under former conditions, and under the production of four times as much per acre; and, of course, the people become bankrupt. It is the same with the wheat crop; the cultivation of large areas, with low production, becomes unprofitable.

When the returns that can be made from the offal and remnants of the crop are not sufficient, it becomes necessary to see how else they can be made most cheaply; because that is a condition of great importance. We can give back one and the same substance in different forms, and it may cost in one form three or four times more than in another. *How to manure most cheaply is the question.*

INGREDIENTS WITHDRAWN BY VARIOUS CROPS.

The table below gives the different ingredients withdrawn by the several crops mentioned, leaving out what is taken from the air by the plant. The portion of the table to the left of the column of "Total Ash" shows the ingredients of the ashes of each crop, in pounds per

AMOUNT OF SOIL INGREDIENTS WITHDRAWN BY VARIOUS CROPS. (Pounds per Acre.)

	Potash	Soda	*Lime*	Magnesia	Brown Oxid of Manganese	Iron Oxid and Alumina	*Phosphoric Acid*	Sulphuric Acid	Silica	Chlorine	Total Ash	*Nitrogen*
GRAPES, 1,000 lbs.	5.00	0.10	1.00	0.40			1.52	0.50	0.30	0.10		1.70
Crop of 10,000 lbs.	50.00	1.00	10.00	4.00			15.20	5.00	3.00	1.00		17.00
Seeds, 646 lbs.	1.48						5.75					
Flesh, 9,154 lbs.	47.44						8.93					
Wood, 2,010 lbs.	15.69	0.67	21.60	3.30		0.42	8.74	1.75	0.64	0.61	53.42	
PRUNES, 1,000 lbs.*	2.66	0.13	0.13	0.25	0.01	0.03	0.53	0.10	0.19	0.01	3.03	1.48
Crop of 30,000 lbs.	79.70	3.85	3.92	7.45	0.38	1.04	15.95	2.87	5.52	0.22	120.90	44.40
Pits, 1,635 lbs.	2.06	0.40	0.52	1.40	0.16	0.10	2.80	0.46	0.68	0.02	8.60	10.30
Flesh, 28,365 lbs.	77.64	3.45	3.40	6.05	0.22	0.94	13.15	2.41	4.84	0.20	112.30	34.10
APRICOTS, 1,000 lbs.*	2.83	0.55	0.18	0.20	0.01	0.09	0.71	0.16	0.41	0.02	5.16	2.29
Crop of 30,000 lbs.	84.98	16.36	5.45	5.96	0.33	2.65	21.38	4.57	12.15	0.94	154.80	68.70
Pits, 1,740 lbs.	1.36	0.42	0.83	1.43	0.19	1.51	5.36	0.65	0.31	0.19	12.25	15.00
Flesh, 28,260 lbs.	83.62	15.94	4.65	4.53	0.14	1.14	16.02	3.92	11.84	0.75	142.55	53.70
ORANGES, 1,000 lbs.*	2.11	0.11	0.99	0.23	0.02	0.04	0.53	0.23	0.03	0.04	4.32	1.83
Crop of 20,000 lbs.	42.28	2.16	19.72	4.61	0.32	0.83	10.60	4.52	0.56	0.80	86.40	36.60
Seeds, 240 lbs.	2.74	0.10	1.32	0.60		0.06	1.61	0.36	0.08	0.04	6.90	
Flesh and rind, 19,760 lbs.	39.54	2.06	18.40	4.01		0.77	8.99	4.16	0.48	0.76	79.50	
Roots, percentage	15.43	5.15	49.89	6.91		1.02	13.47	5.78	1.75	0.72	100.12	
Stems, percentage	11.69	3.20	55.13	6.34		0.57	17.09	4.64	1.22	0.15	100.00	
Leaves, percentage	16.51	5.21	56.38	5.72		0.52	3.27	4.43	4.83	4.03	99.91	
OLIVES, 1,000 lbs.	8.55	0.76	2.32	0.54		0.14	1.18	0.14	80.77	0.23	94.63	5.85
Crop of 2,200 lbs.	18.81	1.68	5.10	1.18		0.30	2.59	0.30	177.72	0.50	208.18	12.86
Pits, 429 lbs.	6.77	0.57	4.01	0.91		0.19	2.40	0.29	177.63	0.48	193.25	9.67
Flesh, 1,771 lbs.	12.04	1.11	1.09	0.03		0.11	0.19	0.01	0.09	0.02	14.56	3.19
Leaves, 4,400 lbs.	58.05	2.10	88.53	8.48		2.72	20.08	9.11	0.81	0.28	190.16	69.90
Wood, 11,000 lbs.	24.46	4.31	66.63	6.30		4.02	14.87	2.00	0.59		123.18	117.67
WHEAT, 1,000 lbs. (whole plant)	9.15	0.35	2.30	1.36		0.39	4.13	1.44	30.52	1.65	51.26	8.75
Crop of 4,800 lbs. (hay)	43.92	1.68	11.04	6.52		1.76	19.80	6.93	146.50	7.80	246.04	42.00
Grain, 20 bushels	7.85	0.14	0.72	2.57		0.22	11.90	0.34	0.24	0.02	24.00	24.00
Straw, 3,600 lbs.	36.07	1.54	10.32	3.95		1.54	7.90	6.50	146.26	7.87	222.04	18.00
ALFALFA, 1,000 lbs.	13.49	0.51	22.86	2.02		0.53	6.43	4.16	13.41	1.59	65.00	12.94
Crop of 12,000 lbs.	161.88	6.12	274.32	24.24		6.36	77.16	49.92	160.92	19.08	780.00	155.28

SUGAR-BEETS (fresh), 1,000 lbs.	5.38	3.09	3.11	2.71	.....	0.23	1.61	1.12	0.62	0.86	18.73	2.38
Crop of 72,000 lbs.	387.44	222.48	224.08	195.60	.....	16.68	116.16	80.64	44.96	61.68	1349.72	173.40
Roots, 40,000 lbs.	152.00	24.00	16.00	24.00	.....	3.00	36.00	12.00	8.00	12.00	287.00	60.40
Tops, 32,000 lbs.	235.44	198.48	208.08	171.60	.....	13.68	80.16	68.64	36.96	49.68	1062.72	113.00
RAMIE, 1,000 lbs.*	8.84	1.76	23.08	5.90	0.12	1.80	6.46	1.70	24.71	1.12	75.19	12.97
Crop of 14.25 tons	251.98	50.14	657.82	168.27	3.57	51.43	155.70	48.56	704.25	51.85	2143.57	369.70
Leaves, 4.25 tons	68.13	8.99	566.91	114.58	1.92	38.56	77.13	30.86	692.71	41.56	1641.35	206.10
Stalk (without bark), 7.25 tons	155.99	33.63	71.77	43.68	1.45	12.16	67.71	14.53	7.06	2.50	410.48	105.85
Bark (cuticle and fiber), 2.75 tons	27.86	7.52	19.14	10.01	0.20	0.71	10.86	3.17	4.48	7.79	91.74	57.75
COTTON, 1,000 lbs.	11.00	4.44	13.76	4.28	.....	2.09	7.03	5.00	4.08	2.58	54.26	.....
Crop of 3,200 lbs.	35.26	14.21	44.04	13.71	.....	6.43	22.54	16.00	13.08	8.27	173.60	.....
Leaves, 400 lbs.	7.99	4.40	15.03	2.50	.....	2.38	4.22	5.84	3.58	2.75	48.69	.....
Stems, 1,200 lbs.	9.17	3.65	10.58	3.56	.....	0.75	4.49	1.99	1.71	2.54	38.44	.....
Seeds, 800 lbs.	8.99	1.15	3.07	4.00	.....	0.52	9.74	1.11	0.31	0.48	29.37	29.20
Burrs, 400 lbs.	7.42	4.59	14.16	3.19	.....	2.66	3.57	6.88	7.40	2.14	52.01	.....
Lint, 400 lbs.	1.69	0.42	1.20	0.46	.....	0.12	0.52	0.24	0.08	0.36	5.09	.....

*Analysis made at the Station laboratory.

acre. Perhaps fault may be found with the estimates of crops upon which these figures are based; but if so, they can easily be brought up or down to any estimates desired by a little calculation on the thousand-weight, also given. On the right of the column of totals is placed nitrogen, a substance not contained in the ashes, but which by most plants is taken from the soil and not from the air, although it constitutes four fifths of it; and which it is highly important to return to the soil.

There are quite a number of ingredients that enter into the plant ash: potash, soda, lime, magnesia, phosphoric and sulphuric acids, etc. All, or nearly all, of these are proved to be necessary to the full development of the plant; but I have distinguished by darker type those which we find it *necessary* to return to the soil, and are therefore willing to pay for. The rest take care of themselves in nearly all soils. *Potash, lime, phosphoric acid*, and *nitrogen* are the four we generally take into consideration. But so far as we of California are concerned, we can do without one of these substances almost throughout the State, at least as far north as Mendocino on one hand, and perhaps Tehama and Shasta, and the higher foothills, on the other. This substance is *lime*, which, from a long series of analyses, I find is almost always abundant in the soils of all arid regions, from climatic causes. Umbrage must not be taken at the application of the word "arid" to California; it is the conventional word for regions of relatively deficient rainfall, where irrigation is required, or at least proves profitable.

I have recently obtained the results of a comparison of some four hundred and sixty soils from the Atlantic Slope (the Cotton States), with more than three hundred from the Pacific Coast (California, Oregon, and Washington), Montana, and a few from the interior (west of the Rocky Mountains). From these data it appears that the average lime percentage in the soils of the Eastern States, where summer rains prevail, is but a little over one tenth of one per cent (0.108 per cent). In California it is just ten times more (1.075 per cent). In the East it is found to be of great importance to supply this ingredient; liming and marling is a common agricultural operation. With us there is rarely any need of this, the lime being naturally present in the soil to a greater extent than can be accomplished by any practicable artificial application; it would be "carrying coals to Newcastle." I therefore leave the lime column out of consideration, in now calling attention to the differences in the draft made upon the soil by different crops.

In making up this table there has been considerable difficulty about getting the needful data, a portion of which are the results obtained in our own laboratory from California materials; these are marked in the table by a star (*). The rest have been drawn mostly from European, also from Eastern sources.

Grapes.—Grapes are placed at the top of the table, as one of the most important crops of the State. You can observe that the draft made by grapes as a whole (fresh grapes) is mainly on potash, and is quite heavy. If we do not return the pomace, the assumed crop of five tons takes away 50 pounds of potash, 15 of phosphoric acid, and 17 of nitrogen per acre.

Plums, Prunes, Cherries.—Take the next fruit, *plums* or *prunes*. There is quite a difference between the amount of potash which a crop of grapes and that which one of prunes or plums takes, but look at the amount of

nitrogen which is withdrawn by the whole fruit; there is a heavy difference there. A fertile soil might be let alone awhile for the nitrogen which grapes withdraw, but it cannot be let alone long if heavy crops of plums are taken off, which take twice and a half times as much as grapes. *Cherries* draw upon the soil, weight for weight, about like prunes.

Apricots.—A crop of apricots draws somewhat more heavily on potash and phosphoric acid than do prunes; in nitrogen the difference is quite heavy, being nearly as two to one; while as compared with a crop of grapes, it is as four to one. So far as we now know, the apricot draws more heavily on the nitrogen than any other fruit crop.

Peaches, Apples, and Pears.—The peach runs somewhere between the plum and apricot; the apple crop is one of the least exhaustive fruit crops for its weight, say about two thirds or three fifths as much as the prune. The pear goes a little higher.

Oranges.—As regards the orange, it does not differ widely from grapes so far as potash and phosphoric acid are concerned; but in the matter of nitrogen the estimated crop of 20,000 pounds takes a little more than twice the amount withdrawn by 10,000 pounds of grapes; yet not as much as prunes, because so much more odd seed goes into prunes than oranges. It may be interesting to state in this connection that the nutritive value of the flesh of the orange is thus considerably higher than is that of the prune (two as against one and a half), but the apricot exceeds the orange in the ratio of two and one third to two.

Olives.—The case of the olive is quite peculiar, if we consider it simply as a source of oil. In the first place, the total *crop* is of much less weight than that of other fruits, yet the total weight of *ash* exceeds considerably that of any other fruit in the table. But when we analyze that ash we find that out of 208 pounds about 178 is silex—that is, flint—which is cheap, and of which all soils contain an abundance. Of the remaining 30 pounds nearly two thirds is potash. There is a trifle of phosphoric acid, and nearly 10 pounds of nitrogen. In these points it is unlike any of the other crops before us; but when we come to consider the product you really want to *sell*—the oil—we fail to find it in this table. The reason is that *as it takes nothing from the soil* it has no place there. *Its entire substance is taken from the air.* So the olive grower who returns all the pomace and other offal to the land from the outset, needs no other manure if his soil is naturally a fairly good one. It is largely for this reason that the olive has maintained itself so steadily in the oldest countries of the world; it does not wear out the soil. But of course, if we take the fruit, pickle it and sell it off, we must make returns to the soil, or our crops will soon fall short. What the olive then specially calls for is potash and nitrogen.

Wheat.—Let us now look at wheat as compared with the fruit crops. A crop of twenty bushels of grain takes out only about 8 pounds of potash; but it takes 12 of phosphoric acid, and 24 of nitrogen. Wheat, then, is not a consumer of potash, like the fruit crops; but it is quite heavy on nitrogen, particularly when we consider the small depth to which its roots penetrate the soil. What wheat draws from only eighteen to twenty-four inches of soil, trees and vines may take from a solid mass of six to ten feet depth. Taking this into consideration, even the 12 pounds of phosphoric acid count heavily; and accordingly it is a matter of experience that wheat culture necessitates specially the free use of phosphate and nitrogenous fertilizers.

Hay.—Now as regards the hay crop: If a crop of wheat is cut for hay, the substances taken from the soil will be very nearly represented by adding together the figures of the table for the grain and straw. When the wheat is cut before maturity, about the same amount of plant (and animal) food is diffused throughout the plant more equally; if the grain is allowed to mature the phosphoric acid and nitrogen accumulate in the grain and the straw remains depleted, hence is a weaker cattle food. When the true grasses are used for hay the outcome is not widely different.

Alfalfa.—Next to wheat, the representative of the true grasses, is placed our great forage plant, alfalfa. It may be taken as representing the clovers at large, and measurably also peas, beans, and the like; the *legumes* we have agreed to call them. It is seen at a glance that it is a heavy feeder, even when compared with wheat-hay (the entire plant), weight for weight. But when we cultivate alfalfa on irrigated land we expect to make three cuts of two tons of hay each, say six tons in all, while of wheat expect only two or two and a half. Of course that makes the figures roll up, and 162 pounds of potash against 44 in wheat-hay, 77 of phosphoric acid against 20, 155 pounds of nitrogen against 42 in wheat, look formidable. In the matter of lime, alfalfa goes ahead of sugar-beets, though it remains far behind ramie. Like the clovers, it needs a limy soil for strong development; and that is one reason why with us alfalfa is so much more prized than "lucerne" is in the East. We have, naturally, just the lime-soils to suit it. But we need not fear that in fertilizing lands for alfalfa we will have to buy all that nitrogen at 17 cents a pound; for, in common with the rest of its kind—the clovers, peas, and beans—alfalfa provides that for itself, from the air. Here is a very important distinction, which alone makes it highly expedient that the vicious practice of calling all forage plants "grasses" should be done away with. The *true* grasses call for heavy supplies of nitrogen that must be furnished by the farmer; the "leguminous" forage plants "rustle for themselves" in that respect, and by using them for green-manuring we can supply the nitrogen required for grain crops much more cheaply than we can buy it from the fertilizer manufacturer. Again, their high content of nitrogen makes their hay specially valuable in putting flesh on our stock. It is not easy to overestimate the value of these nitrogen-gathering plants for general agriculture; and they should not be mixed up with the true grasses that perform entirely different functions in our rural economy.

Sugar-Beet.—Next comes the sugar-beet, in which so many are interested now, and which may be taken as representing the root crops in general. Here we have first, in contrast with wheat and its 246 pounds of ash for the total plant, not less than 1,350 pounds of ash taken from one acre, and if we include the 172 pounds of nitrogen, over three fourths of a ton of total soil ingredients, when the whole plant is removed. It is true that this total comes down to less than 350 pounds if we leave the leafy tops in the field; yet the roots alone remove twenty times as much potash as does wheat, three times as much phosphoric acid, and considerably over twice as much nitrogen. This is an enormous draft as compared with any of these other crops, especially on potash; but phosphoric acid and nitrogen are also drawn upon quite heavily. It will be observed that the draught of beets on all the substance is scarcely approached by any of the crops in the table, except alfalfa and ramie.

But note, also, that the sugar, the commercially salable part of the beet crop, consists of nothing that is in this table at all; like the oil of the olive, *it comes entirely from the air*, and the rest can be given back to the land. The sugar-beet need not, therefore, be an exhaustive crop at all, provided all the offal be returned, which can be done without special difficulty.

Ramie.—Alongside of beets we have another crop which is exciting a great deal of attention—ramie. This also makes a heavy draft upon the soil. If we take the whole plant away, we have taken over one ton of ash in the 14 tons; containing 252 pounds of potash, not quite as much as the beet crop, but still a good deal. Observe the enormous draft upon lime; more than one fourth of a ton of lime is withdrawn per acre; therefore, ramie should not be planted on any soil that has not a great abundance of lime. That is an exceedingly important matter, because the soil would have to be limed within a few years after planting; but in most California soils there is as much lime as ever is wanted, particularly in the valleys. We have that natural advantage over any of the Eastern States that may attempt to plant ramie. The draft on phosphoric acid, also, is enormous. The nitrogen is far ahead of anything on the list; namely, 370 pounds. But this, remember, is largely because of the extraordinary *amount* of the ramie crop we expect to harvest. Over 14 tons of *any* kind of dry product would be very hard on the soil when we take it *all* away. But that is not at all necessary. The part of the ramie plant we are after is the *fiber;* all the rest can go back to the soil and help to produce more fiber. Let us see how much we really have to take away for that purpose. As a matter of fact, the *pure* fiber does not differ from pure sugar in its composition. All but a little ash comes from the air, and does not draw upon the soil at all. But practically we cannot take only the *pure* fiber; the least we can sell is the "crude fiber," the bark of the stalk. Now, this contains only about 92 out of the 2,143 pounds of total ash of the crop, or less than one twentieth of the whole; of nitrogen, only 58 pounds out of 370; of potash, 28 pounds out of 252; of phosphoric acid, 11 out of 156 that would be extracted by the whole plant. The real crop we sell, then, stands somewhere near the fruits—say oranges—in the necessary draft upon the soil.

But it is suggested that ramie growers may as well sell the leaves also, to paper manufacturers, to whom they are a welcome raw material. I greatly doubt that any price the manufacturer could afford to pay would enable you to buy back the heavy amounts of fertilizing material that would thus be carried off. The leaves, as you see, take nearly half of all the nitrogen, that most costly of all soil ingredients, for which you have to pay 17 cents per pound; also half of the total phosphoric acid, say at 6 cents per pound; and over one fourth of the potash of the whole crop, say at 4½ cents. From these figures you can readily calculate what you could afford to sell the leaves for, in justice to your pocket, aside from the loss in vegetable mold so brought about.

There is fortunately no sale for the *stalks;* they are broken into small bits by the decorticating machine, just in good shape to be returned to the field whence they came. But in practice, particularly when you make several cuts in a season, you should put them in piles to rot, with some plaster, to prevent loss of nitrogen. That, with the leaves left on the ground, will give you all the fertilizing material you will need for a number of years, on land that is at all adapted to ramie culture.

In the case of the ramie, the difference between taking the *whole* plant, and the crop part only, is very great; and the farmer should from the outset make up his mind that he *must* make this return to the land, or he had better not start in on ramie culture at all.

Cotton.—But if ramie is a striking example, cotton is still more so. In cotton-growing the only substance usually aimed at is the fiber, the "lint," which constitutes about one eighth of the weight of the whole (dry) plant, and one third of the seed-cotton as picked. In this case the stalks, leaves, and burrs are always returned to the land, as they are of no use otherwise; they are left in the fields, and we have therefore to consider only the seed-cotton. Taking as a basis a 400-pound bale per acre of best upland, we see from the table of totals that all that mass of fiber contains only 5 pounds of ash, and no nitrogen at all; whereas the seed corresponding to it contains nearly 30 per cent of ash, and 29 pounds of nitrogen besides, making nearly 60 pounds of soil ingredients withdrawn by the seed, against the 5 in the lint, the balance of the 400 pounds being taken from the air, as in the case of olive oil and beet sugar. This is so small a proportion of the whole that in a soil of any fair native productiveness the return of the stalk and seed should keep it up for a century at least, if not forever. Here is an actual example: When I left the South in the seventies, a man in Georgia had continued to plant cotton on the same land for fifty years, returning faithfully every year the stalks and seed. That land was then producing more and better cotton than ever, although originally rather poor; about of such quality as would have been exhausted in seven or eight years if nothing had been returned. It is probably producing as well as ever to-day, if the same policy has been pursued by his successors.

But unfortunately he was the exception. The great majority of cotton planters before the war considered cotton-seed as a nuisance, to be gotten rid of in any possible way. It was allowed to rot idly about the gin-houses, making the negroes sick with its effluvia; it was burnt; it was actually hauled across the land on which it had grown, and dumped into the bayous. Then after awhile it began to be sold to the cotton-seed oil factories for a song; and the oil-cake was shipped to Old and New England as a cattle food and fertilizer. Observe that the oil, as in the case of the olive, is no loss to the land at all; but the *oil-cake* contains all the seed did, and is a highly valuable fertilizer.

The farmers of the Cotton States know better now; but no longer ago than 1880 I calculated that they were selling their seed at just about half the price for which they could buy back the ingredients in the form of commercial fertilizers. For ruinous absurdity this whole transaction is probably unique in the history of agriculture. Let us look for a moment at the practical results. In parts of Mississippi and Alabama, uplands that originally yielded a 400-pound bale per acre, and were hard to get at from $50 to $60, have gone a-begging for the taxes; they bore good crops for thirty years, and had the seed been returned would now be better than ever. The whole of the "Southern river counties" of Mississippi, from Vicksburg south, and the rich black prairies of eastern Mississippi, have had this fate. They are now being reclaimed largely by means of commercial fertilizers, at heavy expense, so far as they have not been ruined by the long abandonment and gullying. And just that will be the result everywhere, even in the rich valley of California, unless a different policy is pursued.

HOW TO PREVENT EXHAUSTION OF THE SOIL.

It has been shown what each of the principal crops withdraws from the land; now let us consider what is the best and cheapest policy to pursue in preventing exhaustion—that is, a reduction of the crop below the paying limit. The first rule, as I have insisted in what I have said thus far, is to "return to the land faithfully all that is not very profitably salable." That is the rule to be first of all remembered and practiced. Some portions of crops may be returned directly, as in the case of ramie stalks; or the straw may be fed to cattle, and the manure put back; either way will do, only remember that the cattle carry off a part of the value of the feed with them.

Fertilizers.—The Eastern manufacturers offer as a special recommendation, "complete manures," that is, such as contain, in varying proportions, all of the three critical soil ingredients, potash, phosphoric acid, and nitrogen. That is well where all *are* wanted; but when, as is mostly the case with us, the soil's fertility is used up in a one-sided fashion, one-sided returns are as good as any, and a good deal cheaper. If only one or two of these ingredients are needed, why spend money for those not needed, thus "carrying coals to Newcastle"?

There is a principle involved here that I will formulate as briefly as I can: It is that if of all the ingredients of plant-food, a single one is lacking or is seriously deficient, the presence of all the rest is unavailing. Supply that missing one, and all the rest spring into activity, and your investment yields an enormous profit. *To find out just what the* deficient ingredient is in each case, is therefore a matter of very direct importance to the farmer's pocket.

In part, this question can in many cases be answered from the above table. If the crop grown draws chiefly upon potash, the presumption is that it will be best to supply a fertilizer containing largely that substance. But there is another consideration: Our soils vary as widely as do the crop ingredients withdrawn. Now, if the soil should contain an abundance of available potash, we may after all, in the supposed case, be "carrying coals to Newcastle."

I have already remarked that by far the majority of California soils are rich in lime, so as to render liming, so much practiced in the East, an unprofitable operation here. That knowledge was obtained by analyzing the soils of the State. The same series of analyses has shown that what is true of lime is nearly as true of potash—not quite so much so, for while in the case of lime the proportion between Eastern and California soils is as one to over ten, in the case of potash it is about as one to four in favor of our soils. It is plain, then, that to invest heavily in *potash* fertilizers, as is frequently advised, is likely to be in very many cases a useless expenditure.

Again, I have found that in some parts of the State, the San Joaquin Valley in particular, the soils in many localities contain an abundance of saltpeter, and therefore of available *nitrogen*, for which we would have to pay at the rate of 17 cents a pound. At other points the soil is full of soluble *phosphates;* so that if the crops do not succeed there, it is certainly not the phosphates that are needed to be purchased. Let me mention that such cases belong especially to the regions of the much-dreaded and maligned alkali soils, of which many people are so afraid that the word "alkali" must not even be mentioned in their hearing.

When this matter gets to be properly understood, and people find that *an alkali soil means a rich soil*, requiring only to be rationally treated to become more highly productive than any others around it, the real estate agents will cease to try to hush up their very existence. But as this subject has already been treated of elaborately in the publications of the Experiment Station, I shall now say no more about it than to remind the reader that if he *does* cultivate some alkali soil, there is one substance that it will not need in a life-time; that substance is potash. Few of the alkali soils in this State contain less than 5 or 6 per cent of it. About Westminster, in Orange County, we found over 15 per cent; and at the San Joaquin Valley Experiment Station, near Tulare, we found that what with potash, phosphoric acid, saltpeter, and ammonia, the alkali in the worst part of our land would be worth $7 per ton at wholesale, as a complete, all-around fertilizer. All we will need to do there for years is to check the rise of the alkali by good cultivation, and to neutralize the "black" part of it with gypsum.

Irrigation Waters.—Again, there are the irrigation waters. Some are very pure, and some are not; some carry noxious "black" alkali, others only the "white," and some—particularly in the valley of Southern California—carry so much potash as to render any artificial supply uncalled for, so long as irrigation is kept up. Take the case of oranges at Riverside: an estimated crop of 20,000 pounds will take out of the soil about 42 pounds of potash. But the irrigation water used there will, at the ordinary rate, supply about 35 pounds of soluble potash per annum; and that, in soils which themselves already contain over 1 per cent of potash, by analysis, is pretty sure to keep up the supply without worrying over the importation of potash salts from Germany. It is otherwise in Florida, where not only they do not irrigate, but the soils contain something like a hundred times less potash than do those of California. But these same orange soils of ours are not very rich in phosphoric acid and nitrogen; therefore, I have advised growers to spend their valuable cash for these only, and not for "complete" fertilizers.

Analysis of Soils and Waters.—It will be seen, then, that in order to fertilize intelligently, and as cheaply as may be, we have to know not only what soil ingredients each crop takes away, but also which of them are scarce or abundant in the soils; and where we irrigate, in the irrigation waters. That is the work we are now trying to do at the Experiment Station. The composition of most of the crops we can, on a pinch, get from the work already done in the old country, although we find very considerable differences in composition, arising from the natural differences between old and virgin soils, and also from those of climate. But the soils and waters we must analyze for ourselves, and the job is not a light one; the more as we are short-handed, and have no funds for traveling to make a field survey—an agricultural survey of the State. It seems to me that the State appropriates money for very many less important things.

Meanwhile, the best we can do is to make personal observations when we have the opportunity, and for the rest we must rely on those interested to furnish us samples of soils and waters, along with such information as is always necessary in order to be able to judge intelligently of the value and adaptations of land. The last point is not always considered by those who send us a thimbleful or two of a soil that we see for the first time, and expect us from that to tell them, not only whether

it is best for turnips or fruit, but also the exact varieties of either that will succeed best. Now, we do not claim to operate by witchcraft; we want to know the *facts*—all the circumstances and conditions of soil, subsoil, lay, climate, etc., that may influence crops or cultivation. These we combine with our examination of the soils, and from all that come to a common-sense conclusion. I have prepared a circular that will be sent to any one desiring to know more about his land, with directions how to take proper samples and to give what information is needed for our guidance. In very many cases we already know the soil from former examinations or experience, and can tell what is needed by merely identifying it; in other cases we must first analyze it; and that is a long job, which cannot be indefinitely repeated, short-handed as we are. You may have to wait some time before your turn comes when you have sent a sample; but we will get to it in the end.

The analysis of the *waters* of the State is giving us a great deal of work, and is scarcely less important than that of the soils, in an irrigation country. With the means we now have, all this together is slow work; but we will accomplish it in the end.

State Soil Map.—Of course, what we are aiming at is to make a complete soil map of the State, that shall present as much in detail as possible, the various soil regions and agricultural subdivisions of the State—the foothills, the great valley, the valley of Southern California, and the several subdivisions of the coast ranges. When we shall have classified the soils of these regions, first in general, then in detail, showing what are the virtues and deficiencies and peculiarities of each, we shall be able to answer quickly and fully the thousands of questions now asked from all parts of the State. For the present, we are preparing, with such data as we have, a general soil map of the State for the Columbian Exposition; and for the same we are getting up a set of representative soils from all parts of California.

Fertilizer-Control Law.—There is one thing I must not omit to commend to your earnest attention: It is the need of a "Fertilizer-Control Law," such as now exists in nearly all the Eastern States. The need of such a law arises from the fact that fertilizers are a kind of merchandise that the consumer is altogether unable to judge of, except from the good or evil results of its use; evil, I mean, in the sense of having spent one's money to no useful purpose. Only the chemist can control the intrinsic value of a fertilizer; but unless the law steps in, he can do no more than say what was the value of the sample sent him. What the stuff sold to the farmer may be, he cannot know unless the identity is assured by inspection of every lot put on the market, as is now the rule in the East. For this reason we now decline, at the Station, to make any analyses of fertilizers, save in case of suspected fraud; because the farmer is too apt to assume that so long as he sees a responsible name at the bottom of a column of figures, the stuff is all right.

I will add, in justice to the fertilizer manufacturers on this coast, that I have every reason to believe that most if not all of them give good value for the price asked. One trouble is that farmers are rarely willing to give a sufficiently high price for a first-class article; and thus the manufacturer is often compelled, in order to make sales, to dilute his high-grade material with something (called a filler) that will make up the weight of a ton to correspond with the low price paid. Now, considering the high freights and long distances in this State, one could

much better afford to pay $60 instead of $30 a ton, for a high-grade article; the farmer can then, if he wishes, make two tons of it at home, by putting in any kind of dirt he pleases, and thus at least not have to pay freight on the dirt, as is now frequently done.

All this trouble and uncertainty ought to be done away with by the enactment, next winter, of an effective fertilizer-control law by the Legislature.

Stable Manure.—But before making a practice of buying fertilizers, be sure that first of all, all the offal of the crops, of whatever kind, be utilized on the land; and all the manure, preserved in a proper manner. Which means that the farmer must not allow his manure pile to be first leached of its best soluble portions by rain, and then permit it to "fire-fang" and burn itself out to little more than ash when the dry season comes. Perhaps he has found that when he plows-in long, strawy manure, such as comes from the stables, it frequently not only does no good, but helps to dry out the soil and make a bad stand. That is because we have no summer rains to make it rot in the soil; and yet a portion of the manure is always lost, even by curing it carefully in the pile—some of the nitrogen or ammonia is sure to go off or be rendered unavailable. To prevent this as much as possible, keep the manure pile moderately moist all the time, and always keep some gypsum (land plaster) ready to strew on top of every new addition made to it. That fixes the ammonia, and pays better than to let it waste and then buy from the manufacturer.

Of late there has been some *burning* of manure, with the idea of getting a good fertilizer in the ash. I lately had a sample of such ash from Southern California, sent to me for information as to what a farmer might afford to pay for it. My answer had to be, "Just nothing at all"; because in burning the temperature had risen so high as to make little glass beads of nearly all of the ash; and it would have been of just as much use as these for fertilization, just as in the case of the clinker from straw-burning engines, before mentioned.

It hardly needs to be said that in order to use the manure, as well as the land itself, to the best advantage, a change of crops is desirable whenever feasible. One can thus avoid the one-sided wear, which is good for neither land, tools, beast, nor man, because sure to make any and all of them give out sooner. But as orchardists cannot avoid such one-sided wear, let them put in the cash in one-sided returns, where they will do the most good.

Application of Fertilizers.—As to the time and mode of applying fertilizers, there must be some difference made according to their nature. For instance, if nitrogen in the form of saltpeter is put on in the autumn, the winter rains will wash it through the soil. The same in the form of ammonia salts or tankage would not waste seriously, and would help winter crops. Potash and phosphoric acid may be used at any time, as all but the most leachy soils will retain them anyway. With us especially, the most soluble superphosphates will be made insoluble, though by no means ineffective, so soon as they touch our limy soils. For this reason it will not do here, as it does in the East, to put such fertilizers merely on the surface of the ground, for the rains (or irrigation) to wash in. They are apt to stay right *at* the surface, and if the roots of the trees have to go there for them, when the dry, hot season comes both roots and phosphates will be of little use to the tree. In sandy, pervious soils par-

ticularly, fertilizers must be put far enough down to place them beyond the reach of the summer's heat and drought; cultivate or plow them in, as the case may be. Only the saltpeter is best put on the surface and irrigated in; it is very soluble in water, and remains so, and if it comes too near the roots of orange trees in strong solution it is very apt to do harm.

Drainage.—But however important fertilization may be, it is not all that is needed for the welfare of fruit trees. Most of them require, above all, a deep and well drained, and preferably, a light soil; for instance, it is not worth while to plant cherries or citrus trees in heavy adobe, as some of us have found out to our sorrow. To illustrate: At my home place in Berkeley, where I have a pretty stiff adobe, I planted some cherry trees for family use. They did very well for a few years, evidently until their roots got down into the close subsoil; then they began to droop and quit bearing. Not liking to lose them I laid an underdrain about four feet deep; in a short time the trees revived and are now doing very well. Mr. Wheeler, near Rutherford, Napa County, had an exactly similar experience with cherries and grapes.

Few culture plants and no fruit trees do well with "wet feet." This is just what is the matter in some of our irrigation districts, where leaky ditches have caused the bottom water to rise within a few feet of the surface, not only causing diseased roots, but taking away, by swamping, half or more of the soil that should have nourished the trees and vines. There it will not do any good to fertilize; it is not the lack of plant-food, but the impossibility of getting at it that makes the trouble, and one cannot make a deep-rooted plant do well in a shallow soil. That means underdrainage.

VI. FRUIT AND VEGETABLE PRODUCTS.

INVESTIGATION OF FOOD MATERIALS.

By M. E. JAFFA.

Owing to the great pressure of work in other directions, not as much time has been devoted to this part of the chemical investigations as its importance calls for or as its intrinsic value justifies.

The analyses of sweet potatoes reported on page 219, and the data herewith appended, constitute the work done in this direction. We hope in the next report to present considerably more.

ANALYSES OF ALFALFA HAY, WHEAT, AND ITS BY-PRODUCTS.

For a discussion of the principles involved and of the terms used, see Bulletin No. 100 of this Station, on page 119 of Report for 1891–92.

In Table I will be found the analyses of alfalfa hay and wheat from the San Joaquin Valley, wheat bran, and wheat screenings. The samples of alfalfa hay and of wheat screenings were sent by Mr. W. P. A. Brewer, of San Mateo, and those of the wheat and bran by Mr. J. W. H. Campbell, of San Francisco.

Alfalfa.—In Bulletin No. 100 is given an analysis of alfalfa, which was very unsatisfactory, inasmuch as the sample from which the analysis was made consisted almost entirely of stems. The results here presented have been obtained from a representative sample, and an examination of them will show that they agree quite well with the per cents given for the average of twenty-one analyses of the same fodder grown elsewhere. If the California sample were reduced to the same percentage of moisture, 8.44, given for the Eastern average, it would show somewhat higher figures for the important food ingredients than does that average, as is indicated by the following tabular statement:

	California.	Eastern, Average.
Protein	14.63	14.28
Fat	2.68	2.15
Nitrogen-free extract	46.04	42.68

Wheat.—From an inspection of the data given for California wheat, it will be seen that there is but little variation from the average obtained from three hundred and ten analyses of the same food material grown east of the Rocky Mountains.

Bran.—It will be noted that the bran made in California contains considerably less crude protein, or nitrogenous matter, than does the same by-product from the East, as shown in the averages, by the figures 13.44 and 15.40, respectively. The fat percentage is also slightly lower for the California food. The sample of bran represented by the first

TABLE I. COMPOSITION OF THE FODDERS.

	Number of Analyses.	Original Substance.										Potential Energy in One Pound.	Nutritive Ratio.
		Percentage Composition.						Amount Digestible in 100 Pounds.					
		Moisture.	Pure Ash.	Crude Protein.	Crude Fiber.	Nitrogen-Free Extract.	Crude Fat.	Crude Protein.	Crude Fat.	Crude Fiber.	Nitrogen-Free Extract.		
Hay.													
Alfalfa (California)	1	11.92	5.89	14.10	21.25	44.27	2.57	10.58	1.23	9.77	30.10	960	1:4.1
Alfalfa (Eastern), average	21	8.44	7.44	14.28	25.01	42.68	2.15	10.71	1.03	11.50	29.02	977	1:4.0
Grain.													
Wheat (California)	1	12.07	1.69	11.11	2.75	70.54	1.84	8.90	.77	2.49	61.37	1,376	1:7.4
Wheat (California), average	5	11.35	1.74	11.31	2.60	71.09	2.08	9.05	.87	2.34	61.85	1,399	1:7.3
Wheat (Eastern), average	310	10.50	1.80	11.90	1.80	71.90	2.10	9.57	.88	1.67	63.05	1,419	1:6.9
By-Products, Etc.													
Wheat Bran (California)	1	13.65	3.05	11.90	6.81	61.82	2.77	9.28	1.91	1.70	47.60	1,170	1:5.8
Wheat Bran (California), average	4	12.42	5.61	13.44	8.52	56.41	3.74	10.48	2.58	2.13	43.43	1,151	1:5.2
Wheat Bran (Eastern), average	88	11.90	5.80	15.40	9.00	53.90	4.00	12.03	2.78	2.25	41.47	1,152	1:4.2
Wheat Screenings (California)	1	11.42	2.50	11.20	5.53	66.72	2.63	5.97	1.42	3.04	48.00	1,120	1:9.1
Wheat Screenings (California)	1	10.90	3.39	8.93	5.43	68.55	2.80	4.76	1.52	2.99	49.35	1,126	1:11.8
Wheat Screenings (California), average	2	11.16	2.94	10.06	5.48	67.63	2.72	5.36	1.47	3.02	48.67	1,123	1:10.4
Wheat Screenings (Eastern), average	10	11.62	2.91	12.48	4.93	65.11	2.95	6.66	1.60	2.71	46.88	1,114	1:8.0

analysis was not thoroughly or completely sifted from the flour, which accounts for the very high percentage of nitrogen-free extract, 61.82, as against 56.41 and 53.90, the averages for California and the East, and also for the low contents in ash, crude fiber, and fat.

Wheat Screenings.—The wheat screenings of this State, like the bran, contain less of albuminoids (as indicated by the crude protein percentages) than is found in the same material produced in the Eastern States. This is proved by the figures 10.06 for the average of two analyses of the home product compared with 12.48 per cent stated for the average of ten analyses of the Eastern fodder.

As regards the other constituents of this feeding stuff compared with the Eastern averages, there are not any marked differences to be noted.

COMPOSITION OF FINE AND COARSE FLOUR.

It has been stated that the differences in the results of the analyses of California and Eastern wheats are only very slight; but a comparison of the corresponding analyses of fine and coarse flour, on the other hand, shows a decided discrepancy with reference to the albuminoid or nitrogenous matter.

Upon the completion of the first analysis of California fine flour it was noted that the percentage of albuminoids fell far short of the figure given for the Eastern average obtained from twenty-two analyses. Thinking that perhaps the sample referred to was not a representative one for California fine flour, two others were secured from different sources and analyzed. The results corroborated fully those of the previous analysis, thus proving that the California flour is much poorer in nitrogenous compounds than the Eastern flour of the same quality.

The same statement applies to graham flour.

The table below shows in detail the composition of fine and coarse flour.

Nutrients: Protein.—The marked difference in respect to the albuminoids is seen when comparing the per cents, 7.90 for California, with 11.00 to the credit of the Eastern flour.

Fats and Carbohydrates.—The contents of these two elements of foods are slightly higher for the products of this State than they are for the same material from the East.

Mineral Matter: Ash.—The flours, both fine and coarse, of California and of the Eastern States, contain, respectively, nearly the same quantity of mineral matter, as indicated by the ash percentages. It will be noted under the head of phosphoric acid, that while the percentage of this acid in the ash of the different flours is about the same, amounting to almost one half the ash, when we refer it to the flour as 100, the coarse material shows 0.75 as against 0.23 for the fine flour. This is owing to the total ash in the former case being about three times that obtained for the latter. It must not be supposed that because the coarse or graham flour contains higher percentages of nitrogenous and mineral matter then does the fine flour, it is therefore in proportion more nutritious. The increased amounts of these elements come from the bran, *very little* of which is digested by the human stomach.

Potential Energy.—It will be seen that the figures for potential energy do not differ materially for the several flours. This is due to the fact that in calculating the energy, albuminoids and carbohydrates have the same value.

TABLE II. COMPOSITION OF WHEAT FLOUR.

	Number of Analyses	Water	Nutrients.					Potential Energy in One Pound	Phosphoric Acid Per Cent in Ash	Phosphoric Acid in Original Substance
			Total.	Protein.	Fat.	Carbohydrates.	Mineral Matters.			
Fine flour (California)	1	15.63	84.37	8.75	1.23	73.90	.49	1,588	49.72	.24
Fine flour (California)	1	13.45	86.55	7.17	1.35	77.44	.50	1,629	45.17	.23
Fine flour (California)	1	12.35	87.65	7.79	1.58	77.86	.42	1,659	53.08	.23
Fine flour (California), average	3	13.81	86.19	7.90	1.39	76.40	.47	1,627	49.32	.23
Fine flour (Eastern), average	22	12.50	87.50	11.00	1.10	74.90	.50	1,645	.....	.....
Coarse flour (California)	1	12.12	87.88	8.50	1.96	75.84	1.58	1,650	47.23	.75
Coarse flour (Eastern), average	3	13.10	86.90	11.70	1.70	71.70	1.80	1,625	.....	.....

SUGAR-BEETS.

By M. E. Jaffa.

Sugar-beets, from D. B. Wier, of Trenton, Sonoma County.

"The beets were planted about the first of June on new, rough, but well-prepared mountain land, and received no cultivation whatever. I am sure the seed was not of the best, some of the plants showing red leaf stems. It is a very great mistake to plant beets on rich valley soils carrying great quantities of humus and nitrates. It was tested by thorough experiments on the best prairie soils of Illinois twenty-five years ago, and resulted in a miserable failure. The experiment shows that western Sonoma has many thousands of acres of the very best sugar-beet soils, and best climate in which to work them, where they can be grown to perfection each year with no expensive irrigation."

The samples were received in good condition on September 29th, and analyzed the following day. The average weight of the beets was 330 grams.*

Specific gravity of juice	1.0655
Solid contents of juice	16.00
Sugar percentage of juice	14.125
Purity coefficient	88.30
Saline coefficient	16.51
Ash percentage of juice	.84

These are excellent beets, with proper weight, high sugar percentage, medium ash, and high purity coefficient.

Sugar-cane, grown on the alluvial soil of Andrus Island, Sacramento River; sent by L. F. Smith, of San Francisco. The sample was received on September 14th, and analyzed on the following day.

Specific gravity of juice	1.0800
Solid contents of juice	19.04
Sugar percentage of juice	2.44
Purity coefficient	12.80
Saline coefficient	2.46
Ash percentage of juice	.98

This cane is too poor in sugar and too low in purity coefficient to be worked for sugar.

Sugar-beets, grown on alluvial soil of Andrus Island, Sacramento River; sent by L. F. Smith, of San Francisco. The samples were received on September 14th, and analyzed on the following day. The average weight was 1,300 grams, or 2.9 pounds.

Specific gravity of juice	1.0372
Solid contents of juice	9.30
Sugar percentage of juice	5.06
Purity coefficient	54.40
Saline coefficient	4.86
Ash percentage of juice	1.04

These beets are above the limit in weight allowed at the factories. The solid content of the juice is very low, while the percentage of sugar is deplorably low—less than one half of what it should be. The latter with a very high ash percentage brings the purity coefficient very far below the standard of 80 per cent.

*30 grams equal one ounce.

Sugar-beets, from J. B. Compton, of Williams, Colusa County. The samples were received on October 19, 1893, and analyzed the following day. They had an average weight of 588 grams, or 1.2 pounds.

Specific gravity of juice	1.0678
Solid contents of juice	16.50
Sugar percentage of juice	10.78
Purity coefficient	65.31
Ash percentage of juice	1.38

While of about the right size and weight these beets are below the standard required by our sugar-makers, both as regards purity and sugar contents. Either the seed was not true to name, or, perhaps, excessive irrigation caused the deficiency, for there seems to be no good reason why good sugar-beets should not be grown at Williams.

Sugar-beets, from Williams, Colusa County; sent by J. B. Compton. The samples were received in good condition on October 11, 1892, and analyzed the following day. There were six beets, the average weight of which was 1,107 grams, or more than two pounds.

Specific gravity of juice	1.0352
Solid contents of juice	8.81
Sugar percentage of juice	4.72
Purity coefficient	53.57
Saline coefficient	4.72
Ash percentage of juice	1.00

These beets are above the weight permissible in good sugar-beets. Then, too, the amount of sugar is so low as to make them worthless for the production of sugar. It is probable that the seed was not true to name.

CALIFORNIA SWEET POTATOES.

By M. E. Jaffa and Marvin Curtis.

The sweet potato is such a staple article of food and so important a vegetable that it was desired to test its adaptability to the soil and climate of Southern California. Twenty varieties were planted at the Experiment Station near Pomona. Seventeen of these were analyzed and form the subject of this paper.

As this is our first publication regarding California sweet potatoes, and not having, for this year, any complete data for the samples, concerning the character of the flesh when cooked, the time of ripening of each, or the yield per acre, it may not be out of place to quote, for the varieties examined, from Bulletin No. 28 of the Texas Agricultural Experiment Station, the following table:

TABLE I. YIELD PER ACRE, ETC., OF SWEET POTATOES.

Name of Variety.	Season.	Character of Flesh when Cooked.	Yield per Acre, in Bushels.		
			Merchantable.	Culls.	Total.
1. Bermuda	Late	Light yellow, dry	101.00	24.18	125.18
2. Big-Stem Jersey	Medium	Pale white, dry, and hard	51.90	43.37	95.27
3. Tecotea					
4. Golden Stem					
5. Shanghai (California)	Late	White, rather dry	164.23	35.53	199.76
6. Barbadoes	Late	Bluish white, soft, and strong	17.26	10.89	28.15
7. Early Golden	Late	Yellow, soft, and dry	79.90	18.16	98.06
8. Matejito					
9. Vineless	Early	Light yellow, soft, and mealy	156.45	30.87	187.32
10. New Jersey	Early	Light yellow, soft, and mealy	42.37	7.56	49.93
11. Hayman	Late	Pale yellow, dry, and mealy	31.50	9.00	40.50
12. Dog River	Late	Yellow, soft, and wet	11.24	8.65	19.89
13. Yellow Nansemond	Medium	Yellow, soft, and damp	41.26	30.60	71.86
14. Red Nansemond	Late	Pale yellow, sweet	43.71	8.17	51.88
15. Norton	Late	Dull white, soft, and strong	46.94	7.51	54.45
16. Peabody	Late	Creamy yellow, dry, and hard	82.50	22.96	105.46
17. Pumpkin Yam	Late	Red, soft, and sweet	46.09	29.33	75.42
Average			65.45	20.48	85.93

It is thus seen that the largest yield per acre is 200 bushels, obtained from the Shanghai (California), a late variety. The product of the Vineless is 187 bushels, with early season.

Bermuda and Peabody, both late, show 125 and 105 bushels, respectively.

The lowest amount per acre is 20 bushels, derived from the Dog River variety, which is also late in ripening.

The average is 86 bushels, which is somewhat low, as that for the whole State of Texas is slightly over 100 bushels per acre.

A detailed description of each sample analyzed will be found in the report of Mr. Chas. H. Shinn, Inspector of Stations, on the Southern California Station.

The results of the chemical analyses are given below in Table II, *A* representing the percentage composition of the fresh material, and *B* that of the water-free substance.

TABLE II. ANALYSES OF SWEET POTATOES GROWN AT THE SOUTHERN CALIFORNIA STATION.

Number	Variety.	A. Per Cent on Fresh Substance.								B. Per Cent Calculated to Water-Free Substance.							Number
		Water	Pure Ash	Crude Protein	Crude Fat	Nitrogen-Free Extract.			Crude Fiber	Pure Ash	Crude Protein	Crude Fat	Nitrogen-Free Extract.			Crude Fiber	
						Sugar by Copper Test.		Total Nitrogen-Free Extract.					Sugar by Copper Test.		Total Nitrogen-Free Extract.		
						Before Inversion.	Total, After Inversion.						Before Inversion.	Total, After Inversion.			
1	Bermuda	66.29	1.19	3.42	.56	*	*	25.72	2.82	3.54	10.14	1.66	*	*	76.29	8.36	1
2	Big-Stem Jersey	65.78	1.16	2.53	.74	*	*	26.15	3.64	3.39	7.36	2.16	*	*	76.46	10.63	2
3	Tecotea	62.94	1.35	3.23	.96	*	*	27.89	3.63	3.64	8.71	2.59	*	*	75.27	9.79	3
4	Golden Stem	70.89	1.10	1.58	.64	.79	3.81	22.77	3.02	3.80	5.42	2.20	2.73	13.09	78.20	10.38	4
5	California	75.28	1.01	1.29	.59	1.17	5.17	19.48	2.35	4.09	5.25	2 37	4.74	20.92	78.78	9.51	5
6	Barbadoes	45.81	1.98	2.32	.83	5.64	20.86	43.52	4.54	3.66	4.28	1.54	10.42	38.50	82.13	8.39	6
7	Early Golden	67.03	1.24	2.25	.77	3.23	10.28	26.24	2.47	3.78	6.82	1.72	9.80	31.20	80.16	7.52	7
8	Matejito	67.54	1.24	1.59	.68	*	2.18	25.71	3.24	3.83	4.90	2.10	*	6.73	79.17	10.00	8
9	Vineless	67.91	1.11	2.44	.63	3.14	8.81	25.97	1.94	3.45	7.61	1.95	9.80	27.47	80.93	6.06	9
10	New Jersey	75.96	.70	1.09	1.76	3.16	8.01	18.41	2.08	2.90	4.55	7.34	13.16	33.33	76.57	8.64	10
11	Hayman	68.55	1.14	1.92	.40	*	2.39	25.01	2.98	2.00	6.12	1.28	*	7.60	81.11	9.49	11
12	Dog River	66.36	1.15	2.03	1.35	4.00	7.28	26.25	2.86	3.44	6.03	4.03	11.90	21.64	77.99	8.51	12
13	Yellow Nansemond	72.32	1.08	2.06	1.26	.78	1.96	20.64	2.64	3.91	7.43	4.56	2.82	7.10	74.56	9.54	13
14	Pumpkin Yam	66.91	1.24	1.82	2.50	3.36	8.08	25.72	1.81	3.77	4.25	7.57	10.20	24.50	78.91	5.50	14
15	Norton	67.67	1.21	1.65	.81	2.23	5.92	26.71	1.95	3.75	5.10	2.50	6.90	18.31	82.60	6.05	15
16	Peabody	68.48	1.26	1.87	.57	2.07	3.77	25.53	2.29	4.01	5 97	1.82	6.58	11.98	80.29	7.91	16
17	Red Nansemond	72.73	1.17	1.57	1.77	1.01	1.15	21.18	1.58	4.29	5.77	6.50	3.70	4.22	77.62	5.82	17
	Averages	69.00	1.15	2.08	1.00	2.33	5.55	24.23	2.62	3.60	6.23	3.17	7.73	19.00	78.70	8.35	
	Averages of 21 varieties from analyses made at Texas Agr. Expt. Sta.	70.27	1.14	2.41	.99	3.42	6.81	24.00	1.26	3.83	8.10	3.33	11.50	22.90	80.73	4.25	

* Not determined.

The above analyses show the water to vary from about 76 per cent in the Shanghai (California) to 63 in the Tecotea.

The amount occurring in the Barbadoes is exceedingly small, and due to the fact that the sample was somewhat dry before the analysis was undertaken; for that reason it is not included in the averages calculated from the analyses of the fresh substance.

In order that an intelligent, and at the same time, practical comparison may be made of the different varieties, the results given in Table II have been calculated to a basis of 70 per cent water, that being about the average amount contained in the commercial article. Table III shows the results so calculated.

TABLE III. ANALYSES OF SWEET POTATOES.

(Results calculated to 70 per cent water.)

	Pure Ash	Crude Protein.	Crude Fat.	Nitrogen-Free Extract.			Crude Fiber.
				Sugar by Copper Test.		Total Nitrogen-Free Extract	
				Before Inversion.	Total, After Inversion.		
1. Bermuda	1.06	3.04	.50	*	*	22.89	2.51
2. Big-Stem Jersey	1.02	2.21	.65	*	*	22.93	3.19
3. Tecotea	1.09	2.61	.78	*	*	22.58	2.91
4. Golden Stem	1.14	1.63	.66	.82	3.93	23.46	3.11
5. Shanghai (California)	1.23	1.58	.71	1.43	6.28	23.63	2.85
6. Barbadoes	1.10	1.28	.46	3.13	11.55	24.64	2.52
7. Early Golden	1.13	2.94	.52	2.94	9.36	24.05	2.26
8. Matejito	1.15	1.47	.63	*	2.02	23.75	3.09
9. Vineless	1.04	2.38	.59	2.94	8.34	24.27	1.82
10. New Jersey	.87	1.37	2.20	3.95	10.00	22.97	2.89
11. Hayman	.60	1.84	.38	*	2.28	24.33	2.85
12. Dog River	1.03	1.81	1.21	3.57	6.49	23.40	2.55
13. Yellow Nansemond	1.17	2.23	1.37	.85	2.13	22.37	2.86
14. Pumpkin Yam	1.13	1.28	2.27	3.06	7.35	23.67	1.65
15. Norton	1.12	1.53	.75	2.07	5.49	24.78	1.82
16. Peabody	1.20	1.79	.55	2.07	3.59	24.09	2.37
17. Red Nansemond	1.28	1.73	1.95	1.11	1.27	23.29	1.74
Average	1.08	1.86	.95	2.36	5.71	23.60	2.51
Average of 21 varieties from Bulletin 28, Texas Agricultural Experiment Station	1.14	2.41	.99	3.42	6.81	24.00	1.96

* Not determined.

Ash.—From the above data it will be noted that while the mineral contents, as indicated by the ash percentage, is quite low, the average being only 1.08, there are marked differences between some of the varieties in this respect. The lowest, 0.60, is found in the Hayman. Red Nansemond contains the highest percentage, 1.28, of this ingredient. Shanghai (California), with 1.23, and Peabody, with 1.20, approach quite closely to this latter figure.

Albuminoids or Nitrogenous Matters (Crude Protein).—Of this important food constituent the Bermuda has the most, 3.08 per cent, which is considerably more than the average, 1.86, for the seventeen varieties examined. The Vineless, much in favor in Texas, shows 2.28 per cent. The lowest contents, 1.28, is given both for the Barbadoes and the Pumpkin Yam.

Fat.—This forms only a small part of the composition of the sweet potato. Less than 1 per cent is the average. But five of the samples contain quantities above that figure, viz.: New Jersey, 2.20; Pumpkin Yam, 2.27; Red Nansemond, 1.95; Yellow Nansemond, 1.37, and the Dog River, 1.21 per cent.

Nitrogen-Free Extract.—Starch, sugar, gums, etc., are included under the above head, the former predominating. The total *sugar* reaches a maximum of 11.55 in the Barbadoes and a minimum of 1.27 in the Red Nansemond. Among the high percentages may be noted the New Jersey, with 10.00; the Early Golden, 9.36, and the Vineless, with 8.34.

The Matejito, Hayman, and Yellow Nansemond show extremely low sugar percentages, as indicated by the figures 2.02, 2.28, and 2.13, respectively. The average for the fourteen varieties in which the sugar was determined is 5.71.

The *total* nitrogen-free extract varies but little, in the different samples, from the average, 23.60; the highest figure, 24.78, being stated for the Norton, and the lowest, 22.37, for the Yellow Nansemond.

When comparing the averages for the seventeen samples analyzed with that obtained from twenty-one analyses of different varieties from Texas (Bulletin No. 28, previously referred to) it is seen that the Texas potatoes contain about 33⅓ per cent more *protein*, as shown by the figures 1.86 and 2.41; about the same amount of *fat;* and are richer in total sugar to the extent of one fifth, as indicated by the percentages 5.71 and 6.81, respectively.

The averages, 1.08 and 1.14 for the mineral matter, are about the same, while percentage of crude fiber for the California potato, 2.51, is just double that, 1.26, given for the Texas average.

Further analyses will perhaps tend to lessen these differences, as the samples analyzed from the Southern California Station were the first ones grown there and may have been harvested before maturity.

COMPARISON OF THE COMPOSITION OF THE IRISH AND SWEET POTATO.

The question of the relative nutritive values of the Irish and sweet potatoes often being asked, we append the following little table giving the composition of both.

Not having any analyses of the Irish potato grown in California, we make use of the average of twelve analyses, given in the fourth annual report of the Storrs School Agricultural Experiment Station, Storrs, Conn., for 1891.

TABLE IV. COMPOSITION OF IRISH AND SWEET POTATOES.

	Number of Analyses.	Water, Per Cent.	Nutrients, Per Cents.					Potential Energy in One Pound
			Total	Protein	Fat	Carbohydrates	Mineral Matter	
Irish potatoes	12	78.9	21.10	2.10	.10	17.90	1.00	375
Sweet potatoes (California)	17	70.0	30.00	1.86	.95	23.60	1.08	537

We thus perceive that for a given weight there is considerably more nourishment in the sweet potato than there is in the white or Irish. The potential energy in the latter case is only about two thirds of that contained in the former.

COMPOSITION OF THE ASH OF THE SWEET AND IRISH POTATOES.

To ascertain the amount of mineral matter withdrawn from the soil by a crop of sweet potatoes an analysis was made of the ash. The results are given below. The analysis was made by P. W. Tompkins, a student in the Agricultural Laboratory. The analysis of the ash of the Irish potato, taken from Johnson's "How Crops Grow," is placed alongside for comparison.

	Sweet Potato, Per Cent.	Irish Potato, Per Cent.
Potash	58.16	60.99
Soda	8.12	1.90
Lime	5.64	2.40
Magnesia	4.10	4.60
Peroxid of iron, and alumina	.54	.90
Brown oxid of manganese	Trace.	Trace.
Phosphoric acid	16.17	18.30
Sulphuric acid	2.99	7.00
Silica	2.56	1.90
Chlorine	2.14	2.70
Totals	100.42	100.60
Less excess of oxygen due to chlorine	.42	.60
Totals	100.00	100.00

Of the three most important ingredients: potash, lime, and phosphoric acid, potash predominates and constitutes more than one half the mineral contents of this food. Phosphoric acid amounts to about 16 per cent of the ash of the sweet potato and 18 per cent of the Irish; while the quantity of lime contained is quite small in both cases, not reaching 6 per cent.

The soil on which the potatoes were grown is rich in potash, lime, and phosphoric acid, and fairly well supplied with nitrogen.

DRAFT UPON THE SOIL INGREDIENTS.

The following, based upon the analysis of the ash, shows, in tabular form, the amounts of the important ingredients withdrawn from the soil by a crop of sweet potatoes, and which, except in the case of very rich soils, must soon be replaced by fertilization. By way of comparison is added the corresponding quantities of the same elements of plant food extracted from the soil by a crop of Irish potatoes:

TABLE V. INGREDIENTS WITHDRAWN FROM THE SOIL BY POTATOES.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Sweet potatoes—				
Crop of 1,000 lbs.	10.80	6.28	1.75	3.00
Crop of 5,000 lbs.	54.00	31.40	8.75	15.00
Irish potatoes—				
Crop of 1,000 lbs.	10.00	6.09	1.83	3.40
Crop of 5,000 lbs.	50.00	30.45	9.15	17.00

The amount of potash withdrawn by an average crop of sweet potatoes is thus seen to be about 31 pounds, as against 15 of nitrogen and 8.75 of phosphoric acid. When fertilization is required, the last two named ingredients will probably be the first to be replaced, not because they draw so heavily on the soil, but for the reason that the majority of soils in California have low percentages of phosphoric acid and nitrogen, and high contents of potash.

The figures given for the Irish potato show that while the total amount of mineral matter is, for the same weight, slightly lower than that for the sweet potato, yet the number of pounds of potash extracted is about the same. The amount of phosphoric acid, on the other hand, is a little more than that withdrawn by the sweet potato. The draft upon nitrogen by the Irish potato is somewhat heavier than that caused by the sweet potato.

When we shall be able to compare the analyses of Irish potatoes grown in California with the corresponding data for sweet potatoes, the above conclusions may be somewhat modified.

ANALYSES OF FIGS AND FIG SOILS.

(*Experiment Station Bulletin No. 102.*)

The growing importance of the fig industry in California calls for a full investigation of this fruit, in order to determine as quickly as possible the peculiarities of each variety as grown in the different sections of the State, and thus to gain an insight into their probable commercial adaptations, as well as their nutritive values. In accordance with this plan, already outlined and exemplified with respect to other fruits in Bulletins Nos. 93, 97, and 101 of this Station, such figs as were obtainable of the crop of 1892 have been examined and are here reported upon. The comparatively limited number of samples received thus far does not justify an extended discussion of the practical bearings of the results; yet the fact that they embrace a few of the most important varieties, as well as a number of new ones grown at the University Experiment Stations, lends interest to them. Marked differences will be noted, particularly as regards the proportions of juice, sugar, and acid, as well as in the nitrogen contents which so essentially determine the nutritive value; points of direct importance to the grower as well as to the consumer. The farmer is also specially interested in the amount and kind of ash ingredients and nitrogen taken from the soil by the fruit, since these represent what sooner or later will have to be replaced by fertilization, according to the character of the soil selected for the orchard. In this connection the result of the examination of typical soils that for ages have been used in the production of the best figs of commerce presents great interest, since we are thus enabled to compare them with those of this State that have been, or are likely to be, used in fig-growing, thus gaining a definite basis for their selection.

Producers of these fruits are again invited to communicate with the Station in regard to the examination of their product during the coming season. (E. W. H.)

ANALYSES OF FIGS.

By Geo. E. Colby.

During the season of 1892 eleven varieties of figs were received from several localities in the State and submitted to analysis, the results being given in Bulletin No. 102 of this Station. In 1893 thirty other samples were received and analyzed, and the results are here incorporated with the former. The following is a description of the samples received during both seasons:

Crop of 1892.

No. 1. *White Adriatic*, from Fresno. The name of the grower was not obtained. The sample was received on August 19th in good condition. Its color was greenish-yellow, the fruit very tender, fairly juicy, and very sweet. It is a typical fruit of this kind.

No. 2. *White Adriatic*, from Kern County. It was grown by George A. Raymond. The sample was received in excellent condition on September 2d. A large fruit with an almost cream-yellow color, delicate, juicy, and very sweet fleshed. On page 235 will be found a description and analysis of the soil upon which these figs were grown.

No. 3. *Smyrna* (*?*), from Solano County. It was grown by E. R. Thurber, and the sample received on August 6th in good condition. It was a medium-sized fruit, of a dark-yellow color, and not very tender or sweet fleshed.

No. 4. *Smyrna* "*Bulletin*," from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received on August 17th. It was a smaller but sweeter fruit than No. 3 from Solano County. Its flesh was coarse, but the color good. This fig was from young trees and marked as frost-proof.

No. 5. *California Black*, from Solano County. The sample was grown by E. R. Thurber, and was received in good condition on August 6th. A medium-sized fruit with coarse flesh and rather tough skin; not very sweet to the taste.

No. 6. *Hirtu du Japon*, from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received on August 17th in only fair condition. It was of medium size, with purple color; its flesh was white in color, tender, juicy, and quite sweet. The sample was from young trees, which are prolific bearers and frost-proof.

No. 7. *Constantine*, from Tulare County. The sample was grown at the San Joaquin Valley Experiment Station, and received in good condition on August 17th. It was small in size and with a striped green and purple color. Its flesh was hard and fibrous, but quite sweet. The sample was from young trees and is another of the frost-proof varieties of the station.

No. 8. *Du Roi*, from Tulare County. It was grown at the San Joaquin Valley Experiment Station, and was received on August 17th in good condition. It was fully ripe and had a cream color, but its flesh was hard and rather dry, though quite sweet in taste. This is a new variety, which also has proved its ability to withstand frost. The sample was from young trees.

No. 9. *Dorée Narbus*, from Tulare County. The sample was from young trees grown at the San Joaquin Valley Experiment Station, and

was received in good condition on August 17th. The fruit was very small, and when received its flesh was dry and tough, although very sweet. This variety is also frost-proof, the hardiest of fifty-four varieties at the station.

No. 10. *Pasteliere*, from Tulare County. The sample was received from the San Joaquin Valley Experiment Station on August 17th in only fair condition. It was small in size, with a fibrous and rather tough though quite juicy and sweet flesh. It also was from young trees and of a frost-proof variety.

No. 11. *Brunswick*, from San Luis Obispo County. Grown by Sinsheimer Bros., and received on October 25th. This was a very large fig of dark color. Its flesh was tender, juicy, and very sweet.

Crop of 1893.

No. 35. *White Adriatic*, from Amador County. Grown at Foothill Experiment Station, near Jackson, Amador County. Sample received September 16, 1893, in fair condition. Somewhat smaller than the same named fruit from other localities; shape regular, nearly flat above, stem short; outside flesh greenish-yellow, inside flesh light pink; taste very sweet and rich.

No. 37. *White Adriatic*, from Fresno County. Grown by F. Roeding; received September 27, 1893. A large fruit of nearly oval shape; body of light yellowish-green color, stem end cream colored; stem short and thick; flesh firm and solid, deep pink in color and very sweet.

No. 34. *Dalmatian*, from Tulare County. Grown at Tulare Experiment Station plot. Sample received August 16, 1893. Rather irregularly shaped, one side round, the other bulging. Skin pale brown in color, dry and tough; flesh golden yellow in color, delicate, and melting; a delicious fruit.

No. 36. *Hirtu du Japon*, from Tulare County. Grown at the Foothill Experiment Station, near Jackson, Amador County; received on September 16, 1893. Almost turnip-shaped, with purple skin; firm flesh, of purple color outside, cream colored on the interior; not very sweet. Stalk only of medium length.

No. 30. *Hirtu du Japon*, from Tulare County. Grown at Tulare Experiment Station; received August 15, 1893. A very much larger fruit than that received from Jackson, more nearly round in shape, and had characteristic long, thick stalk; color of skin mostly purple, shading into cream at stalk end; flesh was straw colored, delicate, juicy, and sweet.

No. 31. *Constantine*, from Tulare County. Grown at the Tulare Experiment Station; received August 15, 1893. Fruit full-fleshed, nearly round, but flattened at the apex; stem thick and short, body grayish-purple, running into pale cream toward stalk; flesh dryish and deep pink color.

No. 27. *Du Roi*, from Tulare County. Grown at Tulare Experiment Station; received on August 10, 1893. A pale yellow colored and large fig, with solid flesh of pale straw color.

No. 19. *Pasteliere*, from Tulare County. Grown at Tulare Experiment Station; received August 19, 1893. A medium-sized fruit of fair sweetness.

No. 13. *Brunswick*, from Fresno. Grown by F. Roeding, and received July 5, 1893. Fruit full-fleshed; condition excellent; color of skin purple; flesh tender and melting.

No. 12. *San Pedro (White)*, from Fresno. Grown by F. Roeding; received on July 5, 1893. Condition excellent; fruit large, with yellow-colored body, shading into green at stem; skin thick.

Nos. 14 and 15. *Grise*, from Fresno County, first and second crop. Grown by F. Roeding. No. 14 was received on July 14, 1893, and was brownish-red in color, with very tender flesh. No. 15 was received on August 12, 1893, and was full-fleshed, grayish-brown in color, with rich, tender flesh of quite red color.

No. 17. *Brown Turkey*, from Mission San José, Alameda County. Grown by Professor Hilgard. Color of fruit brown; elongated in shape; flesh juicy and fairly sweet.

No. 26. *Brown Ischia*, from Tulare County. Grown at Tulare Experiment Station; received on August 10, 1893. Fruit flattish-round shaped, pale brown at apex shading into yellow at stem; flesh pale pink in color and of medium sweetness.

Nos. 16 and 39. *Black Mexican*, from Fresno, first and second crop. Grown by F. Roeding. No. 16 (first crop) was received on July 14, 1893, and was dark purple in color, fully ripe, and much larger than the second crop sample. No. 39 (second crop) was received on September 27, 1893. Nearly egg-shaped, short-stemmed, hollow; flesh firm, of reddish-brown color and medium sweetness.

No. 18. *Abondance precoce*, from Tulare County. Grown at the Tulare Experiment Station; received August 7, 1893. Fruit small, brown colored at apex, cream colored at stem end.

No. 23. *Coucourelle blanche*, from Fresno. Grown by F. Roeding; received for analysis August 8, 1893. Skin rather tough; fruit very small and flattened; color pale yellow to green.

No. 25. *Coucourelle noire*, from Fresno. Grown by F. Roeding; received August 8, 1893. A small brownish-purple fig, with delicate skin and medium juicy flesh.

No. 24. *Rose blanche*, from Fresno. Grown by F. Roeding; received for analysis August 8, 1893. Fruit full-fleshed, pyramid-shaped, of dark purple color; flesh juicy and very delicate.

No. 28. *White Celeste*, from Fresno. Grown by F. Roeding; received for analysis August 12, 1893. A very small pear-shaped fig, with very long stalk and pale-violet skin.

No. 29. *Cargigne*, from Fresno. Grown by F. Roeding; received on August 12, 1893. A flattened, roundish-shaped, full-fleshed fruit, with brown apex and cream-colored base; somewhat spotted; flesh juicy, and pale pink in color.

No. 33. *Ravignon*, from Tulare County. Grown at Tulare Experiment Station, and received on August 16, 1893. A large fig, varying in shape, some being pear-shaped, some greatly bulged on one side. In color some were entirely cream-colored, others had brown spots and brown apices, with upper half of cream color. Stem thick and pretty long. Flesh was somewhat hollow, pale pink in color, and was sweet and juicy.

No. 32. *Col di Signora Bianca*, from Tulare County. Grown at the Tulare Experiment Station; received August 15, 1893. Apex flattened,

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body rounded, stem quite thick and short; color light maroon; flesh yellowish-pink in color, pretty juicy and fairly sweet.

No. 20. *Bellona*, from Fresno. Grown by F. Roeding; received on August 8, 1893. Medium-sized, nearly round, with thick stem; color dark purple; center of fruit dry and open; flesh sweet and palatable.

No. 21. *Marseilles*, from Fresno. Grown by F. Roeding; received for examination on August 8, 1893. Very small, irregular-shaped fig, flat on one side and elongated but roundish on the other; color beautiful golden yellow; leathery skin; flesh pink color and dryish.

No. 22. *Missonne*, from Fresno. Grown by F. Roeding; received for analysis on August 8, 1893. Regular roundish-shaped, full-fleshed fig, with medium thick stalk and dark, purple-colored, delicate skin; flesh juicy and pink in color.

No. 38. *Bourjassotte panachée*, from Fresno. Grown by F. Roeding; received September 27, 1893. Fruit large, stalk large and thick, roundish in shape mostly, some flattened on one side; color banana yellow, striped lengthwise with light green bars; flesh solid deep pink and very sweet and juicy.

No. 40. *Zimitzia*, from Fresno. Grown by F. Roeding; received for examination on September 27, 1893. Fruit was nearly round, with yellowish-green delicate skin, and short, quite thick stalks; flesh hollow and juicy, of pink color.

No. 41. *Cernica*, from Fresno. Grown by F. Roeding; received on September 27, 1893. Quite round, medium-sized, full-fleshed fig; skin thin and tough, of purple color marked with minute white spots; flesh sweet and blood-red in color.

DISCUSSION OF ANALYTICAL RESULTS.

The large table contains the results of the physical and proximate analyses of the figs of the crops of 1892 and 1893. We do not try to calculate averages, because we have so few analyses of like varieties, and also because most of the fruits are from young orchards. At the same time it is profitable to discuss these results somewhat, to make clearer some of the points embodied in the tables. The soils on which samples 4, 6, 7, 8, 9, and 10 were respectively grown are described on page 236.

Amount of Juice in the Fruit.—The juiciest fig thus far examined is Rose blanche, No. 24, from Fresno, with *90 per cent;* Missonne, No. 22, has 88.6 per cent juice, and Brunswick, No. 13, from Fresno, shows 86.7 per cent; then the other varieties fall away from these figures to from 75 to 70 per cent juice, till we reach the very dry ones. These are headed by Coucourelle blanche, No. 23, from Fresno, with only *38.5* per cent juice, leaving 61.5 per cent pressed "pulp"; Marseilles, No. 21, has 53.4 per cent juice. The "pulp," as reported, holds in it all the parts of the fig excepting the juice.

Amount of Sugars in the Fruit.—The Adriatics, Nos. 2, 35, and 37, from different localities, and Bourjassotte panachée, No. 38, appear to lead in this important ingredient, having as they do about 20 per cent of sugar. The Smyrna, No. 4, with 19.2 per cent, Rose blanche, No. 24, and Zimitzia, No. 40, both from Fresno, with 18.5 per cent sugar, follow, apparently, rather closely. Those figs showing a poverty in sugars are the California Black, No. 5, and Coucourelle blanche, No. 23, each having but 8 per cent; the Missonne, No. 21, is but little better off, as it

shows only 11 per cent sugar. The bulk of the fruits analyzed run in the neighborhood of from 13.5 to 15.5 per cent sugar; for comparison with other varieties of California fruits the sugar has been averaged, with the result of 15.53 per cent for the forty-one samples studied. (See summary at the end of report on fruits.)

European data at hand do not give any report upon fresh figs, but from the German analyses of dried figs it is easy to calculate, approximately, that the sugar in the whole fresh fruit amounts to 20 per cent, thus showing no advantage over our largely grown White Adriatic figs in sugar contents.

The table below makes it evident that among California fruits, the *figs*, White Adriatics especially, hold no mean place in sugar contents.

Percentages of Sugar and Acid.

No. Analyzed...	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid—Per Cent.	Sugar.	Sugar.	Sugar.
4	Figs, White Adriatic	.21	19.70	----------	19.20
37	Other figs	.10 to .20	10.0 to 29.0	----------	8.0 to 19.20
11	Apricots	.68	13.31	11.93	11.10
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.89
2	Peaches	.24	17.00	13.40	12.50
...	Grapes	.50	24.00	23.00	20.70
80	Oranges	1.28	10.68	7.12	5.40

The *acid* of the figs (expressed in terms of sulphuric (SO_3) for the sake of comparison) seems thus to be very much lower than that found in any of our other fruits.

Nutritive Values—Nitrogen Contents.

The *maximum* nitrogen percentage is 0.414, corresponding to 2.587 per cent albuminoids (proteins) found in Marseilles, No. 21; White Adriatic, No. 2, with 0.36 per cent nitrogen, or 2.256 albuminoids; Dalmatian, No. 34, with 0.308 per cent nitrogen, equivalent to 1.935 albuminoids, and Pasteliere, No. 19, with 0.292 per cent nitrogen, or 1.825 albuminoids, all indicate too great richness.

The *minimum* amount, 0.116 per cent nitrogen, or 0.725 albuminoids, is yielded by White Adriatic, No. 1. Again, for comparison with other California fruits, the average was made for the albuminoids in the figs, and we give 1.522 per cent for the figure. It is used in the table in the summary of this fruit report, showing the amount of *nutrients* in different varieties of fruits.

Without repeating what has been already published by this Station in its fruit bulletins, Nos. 93, 97, and 101, relating to the importance of the *flesh-forming ingredients* (*albuminoids*) of our fruits, we give below, in tabular view, the average amounts of these substances contained in some of the fruits we have examined and considered; added to this are such data from European sources as are at hand.

Average Percentages of Albuminoids.

Fruits.	Number of Analyses Made.	In Whole Fruit—Total.	Calculated to Whole Fresh Fruit.	
			In the Fresh Flesh, or Edible Portion.	In Fresh Pits or Rind.
Figs.				
California	28	1.522	(1.50)	
European		1.420	(1.42)	
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Apples and Pears.				
European		.375		

As heretofore pointed out in Bulletin No. 101, the fig rates *first* in flesh-forming materials among our fruits; apricots and plums, *second;* prunes and oranges, *third.*

Comparison with Dried Fruits.

It is interesting to reproduce, at this point, a summary of the *food constituents* of some of our dried fruits as compared with the dried fig—results already published in Bulletin No. 101. In addition, the analysis of a sample of California raisin is here reported:

Percentage Composition of Dried Fruits.

Contents.	French Prunes, Dried. Edible Portion.	Apricots, Dried. Edible Portion.	Raisins, Muscats.*	Figs, White Adriatic.	Figs, Smyrna (Imp'ted).†	Apples, European.
Water	25.20	32.44	18.95	25.00	21.06	33.00
Ash	1.50	1.38	1.55	2.24	1.80	1.40
Albuminoids (crude protein)	2.80	2.90	4.00	4.50	4.06	1.70
Crude fiber	}					8.30
Nitrogen-free extract	29.77	32.18	2.30	10.11	10.18	21.60
Fat	}					
Sugar	40.53	29.59	72.50	57.60	62.50	32.00
Free acid, calculated as sulphuric (SO_3)	.40	1.51	.70	.45	.40	2.00
Totals	100.00	100.00	100.00	100.00	100.00	100.00

* Samples from the vineyard of R. H. Loughridge, Woodland, Cal.
† Analyzed at this Station.

As stated in previous fruit bulletins, these results are too meager to serve as the basis for a general discussion of the relative food values of the fruits examined. However, we note some wide differences among the nutrients. For instance, the sugars and albuminoids, or crude pro-

tein, show considerable variation; the apricots, like the apples, yielding less than one half as much sugar as the Muscat raisin, which contains nearly twice as much sugar as the prunes, and one and one quarter times as much of that substance as the fig. European analyses of raisins show figures for sugar contents which differ but little from those we give here. Both raisins and figs, with, respectively, 4 and 4.5 per cent albuminoids (flesh-forming materials), stand from one and one half to two times above the other fruits in this respect. The fig yields nearly twice as much ash as the other fruits here reported.

ASH COMPOSITION AND NITROGEN CONTENTS.

In the large table (A) we see the highest ash percentage, viz., 1.16, in Marseilles, No. 21—over twice as much as we have found the average (.577 per cent) to be of twenty-eight samples of figs. The small table (B) shows no greater variation in the composition of the ash than was to be expected.

According to previous bulletins relating to fruits (Nos. 93, 97, and 101), the fig stands *second* in amount of mineral matter withdrawn from the soil, for equal weights of the various fruits. From European data we place grapes *first* in this respect, and from our own findings the orange, lemon, prune, apricot, and plum, *third*. We report in the large table on page 229 an ash analysis of the White Adriatic fig from Kern County, and as the figures there represent a considerable district we can take them as a fair guide, the analysis of the ashes of other fruits from different localities of California having shown that the variations will not be great enough to vitiate the conclusions. But few European analyses of fig ashes are at hand, and their great discrepancies necessitated an analysis by us of the ash of an *imported* fig. The results obtained are given in the accompanying tables, and it will be noted that the figures agree, within the limits to be expected, with those we report for our figs. Thus we are able to correct the data, given in Bulletin No. 101, relating to European fig ashes.

B. ANALYSIS OF THE ASH OF THE FIG.

Whole Fruit.	Place of Production.	Sender, or Origin.	Percentage of Pure Ash	Composition of the Pure Ash.											
				Potash	Soda	Lime	Magnesia	Peroxid of Iron.	Brown Oxid o Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less excess of Oxygen due to Chlorine	Total
No. 2. White Adriatic.	Miramonte Kern Co.	Geo. A. Raymond.	.897	60.13	1.17	9.12	5.32	.84	.19	11.07	4.75	4.85	2.55	99.99	.63	99.36
No. 37. White Adriatic.†	Fresno	F. Roeding	.493	55.43	1.58	13.40	5.66	1.34	.22	12.34	3.29	4.24	2.49	99.99	.62	99.37
No. 34. Dalmatian†	Tulare Expt. Station.	Univ. of Cal.	.657	51.94	4.40	10.18	5.83	4.40	.23	14.87	3.68	3.83	1.11	100.47	.28	100.19
Smyrna*	Asia Minor	Imported		48.60	2.20					11.20						

* Analyzed at this Station. † Analyzed with assistance of Mr. Bioletti, of this Station staff.

Draft on Soils by Various Crops.—The following small table gives the amounts, in pounds, of vital soil ingredients extracted by the different fruit crops (for fruit alone) that will have to be replaced by fertilization. Bulletin No. 101 gives more data relating to European fruit than we need for the present discussion:

Soil Ingredients Extracted by Different Fruit Crops.

Fruits.	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Figs.				
Europe*—				
In each 1,000 pounds	8.00	3.89	.89	2.27
Crop of 15,000 pounds	120.00	58.35	13.35	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70
Grapes.				
Europe—				
In each 1,000 pounds	8.80	5.00	1.52	1.70
California Apricots.				
In each 1,000 pounds	4.91	2.90	.64	1.74
Crop of 30,000 pounds	147.30	87.00	19.20	52.20
California Prunes.				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
California Oranges.				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60

*Imported—analyzed at this Station.

With the exception of the grape, it seems that the fig draws rather more heavily upon the mineral ingredients that will need to be replaced by fertilization than do any of the other fruits we have examined; following closely the amounts taken up by the grape and fig of foreign growth. Apricots and prunes, like the oranges, do not in any case draw nearly so heavily upon the mineral matters as the fig; lemons and plums, however, very nearly approach it. And among the figs we note that the White Adriatic stands somewhat above the other figs in this respect. As to nitrogen, it is readily seen that among our fruits the figs, on the whole, draw decidedly the highest amount, and are quite like those of foreign production in this regard. Here, again, the White Adriatic appears to lead.

Potash.—In the ashes of the fig, as in the prune, apricot, orange, and lemon, we find potash to be the leading ingredient, amounting to about three fifths of the whole ash. From the partial ash analysis, given above, of the imported Smyrna fig, we find the potash to be four fifths as much as is contained in the ashes of figs of California growth. We may, however, say for the fig, as for other California fruits, that although potash constitutes so large a portion of the ash of these fruits, its replenishment to the soil will be delayed long beyond the addition of other fertilizing ingredients, because most California soils are naturally so well stocked with it that available potash for the current demand will be adequately supplied for many years.

It will be noted below in the soil discussion that the average percentages of potash for both California and Asia Minor soils is nearly identical.

Phosphoric Acid.—The fig, like the lemon, appears to range a little below the other fruits in its draft upon this material, for we find the ashes to stand in the following order in their phosphoric acid percentages, viz.: Prunes, 14.1; apricots, 13.1; oranges, 12.4, and lemons and figs, 11.1. The European data relating to this subject give for phosphoric acid a figure about the same as that we have obtained for our figs. Since our soils usually contain a very limited supply of phosphoric acid, on the average only about one fourth that given below for Asia Minor soils, our fig, as well as prune, apricot, and orange orchards, will require *phosphatic* fertilizers first.

Nitrogen.—As above stated, the fig leads among our fruits in its demand upon the soil for this substance, apricots only coming near it in this respect. Thus we find that, for the southern localities especially, the same necessity of early replacement of nitrogen in figs and stone fruit as for orange orchards, and partly for the same reason, viz., that California soils are usually not rich in their natural supply of this substance; however, they contain about double that found in the Asia Minor soils, as indicated by the *humus*.

Lime.—Of the other ash ingredients, the lime in the fig ranges about twice that in the prune, and three times that in the apricot, while the orange and lemon show some two and one half to three times more. As our soils usually contain plenty of lime, even for oranges, only in exceptional cases would there be any necessity of replacing this ingredient by fertilization.

FIG SOILS.

By M. E. Jaffa.

It is not intended to make a complete discussion of fig soils, but merely to present the analyses of the soils from the Asia Minor districts, whence comes the Smyrna fig of commerce; and by way of comparison, we give some analyses of typical soils from different regions in this State where fig culture seems to succeed.

With the exception of the analysis of soil No. 1466, from Miramonte, Kern County, published here for the first time, all the descriptions, analyses, etc., of the California soils are taken from previous reports of this Station.

Unfortunately, we have for the Asia Minor soils no data regarding the area which each soil analyzed represents, the depth of the soil, distance to water, the natural growth, etc.

Asia Minor Soils.

A. *Soil from Smyrna*, Asia Minor; received at the University May, 1891, with some fig cuttings, imported by the U. S. Department of Agriculture. It is a calcareous loam, dark gray in color; somewhat plastic on wetting and kneading; contains fragments of limestone, together with considerable fine quartz gravel.

B. *Soil from Erbelli*, Asia Minor; said to grow the finest commercial figs. The sample was sent by Geo. C. Roeding, of Fresno, Cal. This is

a micaceous sandy soil, of light buff tint, does not become plastic on wetting and kneading, and consists almost entirely of fine earth. It shows effervescence with acids.

C. *Soil from Erbelli*, Aidin District, Asia Minor. The sample was sent by D. Van Lennop, Auburn, Cal. It is a sandy gravelly loam, light in color; shows no plasticity upon wetting and kneading. The soil contains quite a large amount of coarse gravel and does not effervesce upon the addition of acids.

California Soils.

No. 1466. *Sandy loam soil*, from S.W. ¼ of Sec. 17, T. 26 S., R. 23 E., Miramonte, Kern County; sent by Geo. A. Raymond. It consists almost entirely of fine earth; the original vegetation was tar weed and pepper cress. It is of a dark buff tint, becoming somewhat plastic on wetting and kneading. Mr. Raymond writes, under date of September, 1890, regarding this soil:

"Top soil from fig orchard, a quite large streak running from southeast to northwest, and comprising about two hundred acres. Everything does well in this soil, even when new and without previous cultivation. The growth of weeds last spring was tremendous. The figs (White Adriatic) are now in the third year from the nursery, with trunks from 4 to 6 inches in diameter, and corresponding tops. The trees have made a heavy growth this year, though setting but little fruit. The soil bakes hard when flooded, but is tillable when moist."

The analysis of this soil shows it to contain high percentages of potash, lime, and phosphoric acid, the latter approaching very nearly to three times the average for California soils. The nitrogen, as indicated by the humus, is in fair supply.

No. 1159. "*Sandy soil*, from the Experiment Station tract, near Tulare City. It is of a buff tint, quite sandy, not assuming any plasticity on wetting and kneading, and capable of tillage at all times. Originally timbered with scattering but large white oaks. Sample was taken to the depth of 12 inches; at 18 to 20 inches the color changes slightly toward yellowish, but the texture continues unchanged; at 36 to 40 inches there underlies a more compact material or hardpan, fairly coherent, and of somewhat finer texture, preventing leachiness. It effervesces with acid."

This soil, as may be seen from the analyses given in the table below, is rich in potash and lime, and contains an adequate supply of phosphoric acid. It is very low in humus in the spot sampled, but doubtless this is not the case throughout, judging from the appearance of the land. Its high percentage of soda tells of the vicinity of alkali spots. So far as can be judged, this soil is fairly representative of the higher portion of the sandy plains generally from Kern to Stanislaus County.

No. 570. *Alluvial soil*, 12 inches; from the Eisen vineyard, Fresno County. It is reddish-brown in color, only moderately heavy, with much coarse sand intermixed; and easily tilled, except when very wet. This soil represents the alluvium of the minor streams heading in the foothills. The phosphoric acid in this soil is very low; but this deficiency is in some respects modified by the great depth and perviousness of the soil. The supply of lime is abundant, and that of potash above the average.

Nos. 971 and 972. *Dark gravelly loam soil and subsoil*, from the vineyard and orchard of Mr. J. A. Sladky, Mountain View, Santa Clara County.

The soil is a mouse-colored clay loam, intermixed with a good deal of gravel; some of the latter quite coarse, and both rounded and angular. The lumps of dry soil can be crushed between the fingers with some difficulty, and on wetting it becomes only moderately adhesive.

This soil represents the extreme western edge of the sloping, gently rolling plain that forms the western portion of the Santa Clara Valley, southward of Mountain View. Along the streams the soil is of great depth, sometimes showing hardly a perceptible change for 12 or 15 feet in depth, and the roots of trees are found penetrating freely to such depths in the gravelly material. This great depth, perviousness, and perfect drainage would constitute alone no mean advantage, if the soil were only of moderate fertility. But the analyses show a very good supply of plant-food. The potash, lime, and humus are high, and the phosphoric acid is found in very fair amounts. It is true that these percentages apply to only one half of the soil-mass, the rest being gravel. But the great depth and easy permeability of the soil more than make up the difference, in comparison, *e. g.*, with an adobe soil of similar composition.

These soils may be considered as well adapted to the production of almost any fruit consistent with the local climate.

No. 110. *Soil of Putah Valley*, near Dixon, Solano County; sent by Mr. J. M. Dudley, from the "middle land" of the plain, on the slopes of the swales, about 3 feet above the lowest land. Depth taken, 12 inches.

This soil is representative of the rich alluvial plains of Yolo and Solano Counties, the soils of which are of prominent fertility, being a mixture of the finest natural sediments of the Sacramento River, with those carried by the streams heading in the volcanic portion of the Coast Range (of which Cache and Putah Creeks are the chief). The plain is scarcely broken by the slight swales or undulations coming down from the foothills; but the region is thickly settled and is largely occupied by orchards and vineyards. The analysis of this soil confirms the experience stated above, relating to the fertility of the soils of this section. The amount of potash is large, and that of lime and phosphoric acid adequate.

No. 766. *Granite soil*, from near Loomis (formerly Pino Station), Central Pacific Railroad, Placer County; sent by E. W. Maslin, of Sacramento, who thus describes the soil:

"There are about 80 square miles of such land lying between Boulder Ridge and the North Fork of the American River, and between Roseville on the south and Auburn Ravine on the north. The ground is gray when dry; when damp, it is brown or reddish. In places the soil is from 9 to 10 feet deep, in some places not over one foot. The subsoil also varies in depth and character; on the hills it rests on a red, rotten granite, into which the roots of trees and shrubs penetrate. It has been dug with the pick to the depth of 20 feet. In the valleys there underlies a gritty clay, here called 'cement,' but also penetrable by roots. Water is within 10 to 12 feet of the surface of the hills in summer. The natural growth is live oak, white oak, digger and nut pine, chaparral 8 to 10 feet high, abundance of poison oak, and California holly. The growth

of the fig tree is very satisfactory. I do not irrigate, and my observation is, that the fig tree *as a producer* of first-class figs does better in the foothills than in the valley. Where the soil is too rich the tree is apt to overgrow and go to wood instead of fruit."

The hill soil, which seems to be a typical one, is a reddish-gray sandy loam, the sand mostly coarse, and consisting largely of granitic debris; it should till easily at all times. The subsoil below the depth of 12 inches is somewhat lighter colored and more sandy. The soils from the depression or valleys seem to differ from the hill land mainly in being somewhat heavier and also of a darker tint.

No. 764. *Valley soil*, from same locality as No. 766. A brownish, dun-colored, rather sandy loam, darkening materially on wetting, and becoming but slightly plastic. Contains much coarse granitic debris. Sample taken to depth of 12 inches.

The subsoil of this land is more reddish and somewhat sandier than the surface soil, the sand being decomposed micaceous granite, increasing downward. Beneath the subsoil, at depths varying from 3 to 10 feet, is a porous, sandy hardpan (cement), quite coherent from clayey binding material, and not readily penetrable by roots. Beneath this comes "rotten" granite, sometimes to 20 feet depth, in which the feldspar masses are kaolinized.

These two granite soils show the usual large amount of inert material (granitic sand or debris), which naturally depresses the plant food percentages. The valley soil differs from that of the ridges, as might be expected, in somewhat higher percentages of lime—of which substance, however, there is enough in both—and of phosphoric acid, of which the supply is small in both, and will doubtless be the first deficiency to be supplied. Potash is present in adequate amounts, and humus is in fair supply, especially in the valley soil, causing the higher absorption of moisture as compared with the ridge soil. In both, however, that factor is low; hence, irrigation would doubtless be very beneficial to the thrifty growth of the crops. The somewhat slow progress of vines and trees in the granitic soils of the foothills is at many points a matter of popular remark and complaint.

No. 51. *Red surface soil*, from near Auburn, Placer County, taken 12 inches deep; sent by Mr. N. S. Prosser, of Auburn. Original vegetation: oak, pine, manzanita, and chaparral.

This is a fair sample of the red soil of the placer mines, which seems to contain a small amount of gold everywhere, and has been washed on a small scale ever since the discovery of gold in California. It is of a dark, orange color, rather light in tillage, and pulverulent when dry, forming a very fine reddish dust. It contains throughout numerous fragments of slate, more or less decomposed, of all sizes, and is usually underlaid by the same, or its debris, at a variable depth, rarely less than several feet, unless lying on steep slopes. The soil becomes slightly plastic on wetting, and can be worked soon after rains; its color darkens considerably on wetting. When dry its lumps are easily crushed between the fingers.

The Auburn soil, a typical slate one, differs from the granitic soils of Pino in one very essential respect: it has on the ridge land over five times as much phosphoric acid as the soil, and four times as much as the subsoil, derived from the granite. In other respects it does not differ widely, except that it contains much less inert matter, as indicated by

the insoluble matter. But its well-known high production, both in quantity and quality, and its thriftiness, confirm the forecast given by the analysis. Practically the same soil prevails near Newcastle, and to the southeast of Penryn, all localities noted for the production of fine shipping fruits.

It will be seen from an inspection of the analyses of the Asia Minor soils that they are all exceedingly well supplied with lime and phosphoric acid, and in the case of soil B from Erbelli district, notably also with potash. This latter soil appears, apart from the humus contents, to be the richest, with its 1.09 per cent of potash, 1.96 of lime, and 0.29 per cent of phosphoric acid. It does not contain as much lime and phosphoric acid as soil A from Smyrna, which shows 4.44 per cent and 0.37, respectively, but the potash percentage is just double that found in soil A, and figs draw quite heavily on this very important ingredient. The Erbelli soil B has another very striking advantage over both the others, in that while the latter have 35 and 40 per cent, respectively, of coarse material, it has only 1 per cent of these.

The percentages of potash and lime in the Erbelli soil C are somewhat below those of the other two, while in phosphoric acid it rates the same as B.

When comparing the nitrogen contents as indicated by the humus percentages, we note a marked deficiency in soil B, with only 0.27 per cent. The figure for soil C, 0.44, about one and two thirds times that of soil B, is only fair; and in soil A, showing nearly three times as much humus as does soil B, is satisfactory.

The moisture absorption coefficients are low in both soils B and C, and only fair in soil A. The highest factor in A was to be expected, owing to its rating so much ahead of the other two in humus.

The comparison of the analyses of the Asia Minor soils with those from this State, shows very strikingly the richness in phosphoric acid of the former over the latter. The lowest per cent of this ingredient in the Asia Minor soils, 0.29, found in soil B, from Erbelli, is more than one and one third times as much as the highest (0.22) shown in the soil No. 1466, from Miramonte, of the California soils; and the average, 0.32 per cent, of the three Smyrna soils is almost exactly four times the average for *all* California soils examined (about two hundred in number), and nearly three times the figure, 0.113, representing the average of phosphoric acid for four hundred and sixty-six soils of the humid region (east of the Rocky Mountains) of the United States.

With reference to lime, the average for the Asia Minor soils is 2.60, as against 1.08 for California. The figures, 0.690 for Asia Minor, and 0.644 for California, representing the averages for potash, show that both sets of soils are about equally well supplied with this element of plant-food.

A marked difference, in favor of California soils, is at once seen when the humus percentages are compared. The average for the Asia Minor soils is only 0.47, being less than one half that, 1.08 per cent, found for the average of one hundred and ninety-eight California soils.

Below is a tabular view of the averages just discussed:

Average Percentages of the Important Ingredients in Soils of Arid and Humid Regions.

	Arid.		Humid.
	California. Average of 198 Soils.	Asia Minor. Average of 3 Soils.	United States, East of Rocky Mountains. Average of 466 Soils.
Potash	.644	.690	.216
Lime	1.078	2.600	.108
Phosphoric acid	.083	.320	.113
Humus	1.040	.470	2.390

The above little table conveys another forcible illustration of an arid region showing far greater amounts of potash and lime in its soils than does a humid one.

ANALYSES OF CALIFORNIA ORANGES AND LEMONS.

By GEORGE E. COLBY.

The data here given comprise descriptive notes upon citrus fruits of the crop of 1893, together with tabulated proximate analyses of twenty samples of oranges, and nine samples of lemons of the same year. A portion of the work (averages) already published will also be found herein as indispensable for comparison; and the whole a continuation of the work presented in Bulletin No. 93 of this Station. It will be of interest to note that we give here, for the first time, some analyses of oranges and lemons grown, or raised, on *sour stock* (*Citrus bigaradia vulgaris*), viz., Washington Navels, St. Michaels, Malta and Ruby Blood oranges from Riverside, and Royal Messina and Villa Franca lemons from Nordhoff and South Riverside, respectively. Other new items are the analyses of the Jaffa, Star, Parson Brown, Du Roi, and Pineapple oranges.

ORANGES.

Description of Samples Received (Crop of 1893).

(For description of oranges of the crop of 1891 received, see Agricultural Report, 1890, pages 107–109, or Bulletin No. 93; for crop of 1892, see Report for 1891–92, pages 99–101.)

No. 75. *Navel*, from Riverside, San Bernardino County. Grown by T. P. Edwards. The sample is from a lot that was awarded the second premium at the State Fair at Colton, and was produced on sour stock. It was received here on March 27th. Fruit was medium in size, rounded in shape, with the thickish skin separating very readily from the flesh; the cell structure of the flesh, while somewhat coarse, was still very crisp and juicy; the taste and flavor were excellent.

No. 91. *Navel*, from Riverside, San Bernardino County. Grown by T. P. Edwards, and not exhibited at the fair. The sample was received on April 27th. There was no difference between this and the earlier sample, save that the skin of the later clings more closely to the flesh;

the juice was very sweet. Mr. J. E. Cutter, through whom we obtained these oranges, writes on April 8, 1893: "We do not assert that the fruit is necessarily better on sour stock, but only that it *will bear comparisons.*"

No. 68. *Navel*, from Porterville, Tulare County. Grown by George Frost. The sample was received on March 3d in good condition, with high color. The skin and "rag" were heavy and very thick; the flesh coarse, but quite tender and juicy, and with a very agreeable taste.

No. 74. *Seedling*, from Porterville, Tulare County. The sample was grown by J. W. Prettiman, and received on March 3d. This was a fruit of high color, large size, and fine appearance, with a thick skin and "rag," somewhat coarse and tough flesh, well-developed seeds, and tart yet very sweet juice.

No. 77. *Mediterranean Sweet*, from Colton, San Bernardino County. Grown by A. S. Fox, and is from a lot that was awarded the first premium at the State Fair at Colton. The sample was received here on March 27th in very good condition. It was of the usual size and somewhat elongated in shape; the skin and "rag" fairly thin, the flesh coarse structured but juicy, and the seeds few and poorly developed.

No. 72. *Mediterranean Sweet*, from Porterville, Tulare County. The sample was grown by George Frost, and received on March 3d. It had a high color, very thick skin and "rag," and a watery taste.

No. 81. *St. Michael*, from Colton, San Bernardino County. The sample was grown by James Barnhill, and is from a lot that received the first premium at the State Fair at Colton. The sample was received on March 27th. It is an orange of fine appearance, with a thin lemon-yellow colored skin, which separates very easily from the pulp. The flesh was not very tender, but quite tart and pleasant to the taste.

No. 76. *St. Michael*, from Riverside. Grown by J. E. Cutter on sour stock. The sample was received for analysis on March 27th. It was a typical orange of its kind—very thin skinned; the seeds few, but very well developed; the flesh very tender and juicy.

No. 71. *St. Michael*, from Porterville, Tulare County. Grown by J. W. Prettiman, and received on March 3d. It had a high color; a skin thick for the variety, but not heavy; juicy and tender flesh, and well-developed seeds.

No. 79. *Malta Blood*, from Riverside. Grown by T. P. Edwards. The sample was taken from a lot that received the second premium at the State Fair at Colton. It was raised on sour stock, and the samples were received on March 27th, in good condition. They varied in shape, one being well rounded and the other elongated in shape. They were of the average size, with a thick skin and "rag," easily and cleanly separated from the flesh; the flesh was of very fine texture, tender and juicy; the juice very red, much more colored than that of the Ruby Blood (No. 78); the seeds were abortive.

No. 73. *Malta Blood*, from Porterville, Tulare County. Grown by George Frost. The sample was received on March 3d. It had a high color, thick skin, juicy but coarse-textured flesh, and a juice only just red-colored.

No. 78. *Ruby Blood*, from Riverside. Grown by J. E. Cutter. The samples were raised on sour stock, and received for analysis March 27th. They had a deep reddish-yellow skin; the "rag" and skin were heavy and thick; the flesh and juice pale red in color, and of coarse texture, but tender and juicy; the seeds few and poorly developed.

No. 69. *Ruby Blood*, from Porterville, Tulare County. Grown by Geo. Frost. The sample was received on March 3d. It was highly colored, and had a thick skin and heavy "rag"; the flesh was coarse, but tender and juicy, and with very pleasant acidity.

No. 80. *Riverside Seedling Blood*, from Riverside. Grown by J. E. Cutter on a tree budded on sour stock. It was received March 27th. The sample was smaller than the other (Riverside) Bloods, but about the same in color; the skin and "rag" were thick, peeling off easily; the flesh was coarse in texture, tender and juicy; the color of the juice was darker, if anything, than that of the Ruby (No. 78), both juices being very tart to the taste.

No. 67. *Jaffa*, from Porterville, Tulare County. The sample was grown by Geo. Frost, and received on March 3d in very good condition. The skin was rough and brilliantly colored; the samples were both rounded and elongated in shape, and rather larger than the ordinary Seedling—in fact, nearly as large as a Navel; the flesh was tender and juicy.

No. 70. *Star*, from Porterville, Tulare County. The sample was grown by Geo. Frost, and received on March 3d. Its color was high, its rind and "rag" very thick, and its pulp tender and juicy.

No. 82. *Parson Brown*, from Riverside. The sample was grown by J. E. Cutter, and received on March 27th. It was round in shape, with flattened base and apex; its skin thick and slightly ribbed, quite rough, and red colored, and separated very easily from the flesh; the flesh was tender, juicy, and pleasant to the taste.

No. 83. *Du Roi* (true ribbed), from Riverside. The sample was grown by J. E. Cutter, and received for analysis on March 27th. The fruit was rather elongated in shape, the base and apex being flattened; the skin was ribbed and rough, with thick "rag"; the flesh was quite tender, but "watery" to the taste.

No. 84. *Pineapple*, from Riverside. The sample was grown by J. E. Cutter, and received on March 27th. It was brilliantly colored, round in shape, somewhat ribbed and rough-skinned, the base and apex flattened; the skin and "rag" were thick and easily separated from the flesh; the flesh was tender and had a distinct flavor of pineapple.

No. 92. *Tardive* (*Valentia Late*), from Riverside. The samples were raised on sweet stock by T. P. Edwards, and received for analysis on June 8th. They were more rounded in shape than those examined in former crops, but still they were slightly elongated; the rind was quite thick, but separated easily from the flesh; the flesh was very tender and juicy; the juice was sweet, and the acid pleasant.

Discussion of Analytical Results.

The accompanying table gives the results of the analyses of citrus fruits of crop of 1892–93, just described above, and *averages* of analyses of those fruits of the crops of 1890–91 and 1891–92, which were reported and discussed in Agricultural Reports for the years 1890 and 1891–92. The question of the distribution of nitrogenous materials in these fruits has now been more fully worked out than formerly, thus giving us some more definite information than is set forth in European reports (referred to in our paper in Agricultural Report for the year 1890, page 112) upon the contents of nitrogen in the *flesh* and *rind* of citrus fruits.

Number

75
91
68

74

77
72

81
76
71

79
73

78
69

80
67
70
82
83
84
92

As indicated above, in referrring to the late reports of this department, we shall only discuss in a brief way some of the main features shown in the table.

Proportion of Rind to Flesh.—The additional data for the year 1893; in the tables relating to the proportion of skin to flesh, in no way change the previous conclusions, but only verify them. Thus the consumer finds that the largest orange—the Navel—has but little, if any, advantage, because of its size, over the smaller Seedling, Mediterranean Sweet, St. Michael, Bloods, and Tardive oranges. The average percentage ratios, as given in the following table, show that on an average the Navel consists of about 72 per cent of flesh and 28 per cent of rind; the average Seedling 75 per cent of flesh and 25 per cent of rind; the average Mediterranean Sweet, Malta and Ruby Bloods about 70 per cent of flesh, with 30 per cent of rind; while the two varieties, St. Michael and Tardive, yield 80 per cent of flesh and only *20 per cent* of rind, or from 8 to 10 per cent less waste material than the other largely grown varieties of oranges just named.

The Riverside Navels of the last crop (Nos. 75 and 91), with 75 per cent of flesh, show a very material advantage in amount of flesh over that from Porterville (No. 68), which has but 64 per cent. They rate on the whole higher in flesh than the majority of the earlier crop Navels, with the exception of No. 4 (1891), from Riverside, and No. 8 (1891), from Pomona. Among the St. Michaels, the Riverside sample, No. 76 (1893), leads for that year with 85 per cent of flesh and 15 per cent of rind; still these figures are outdone by the results of the previous year (1891), in which No. 15, from Pomona, has 85.6 per cent of flesh and 14.4 per cent of rind. The Porterville St. Michael, No. 71, with 80.5 per cent of flesh, is quite within the average. The Bloods from both Riverside and Porterville, Nos. 79, 73, 78, and 69, run very much alike in flesh percentages, varying but little from the average given above. The Parson Brown orange, No. 82, and the Riverside "Seedling" Blood, No. 80, with about 63 per cent of flesh, are but little poorer than either the Star, No. 70, or the Pineapple orange, No. 84, which have about 66 per cent of flesh and 34 per cent of rind. The Du Roi, from Riverside, No. 83, and the Jaffa, No. 67, from Porterville, each have about 70 per cent of flesh, thus rating like the Bloods.

An analysis (reported in Bulletin No. 17, Florida Experiment Station) of the Jaffa orange gives for the peel, or rind, 23.49 per cent of flesh; for the seeds, 0.76 per cent, and for the pulp and juice (flesh), 76.74 per cent; the latter figure being nearly 7 per cent higher than that yielded by Jaffa, No. 67, from Porterville.

Average Percentage Ratios.

Variety.	No. of Samples.	Proportion of Rind to Flesh.		Proportion of Pulp to Juice in Flesh.	
		Rind.	Flesh.	Pulp.	Juice.
NAVELS.					
Crop of 1885	4	29.0	71.0	32.0	68.0
Crop of 1891	5	28.4	71.6	39.0	61.0
Crop of 1892	4	28.2	71.8	41.0	59.0
Crop of 1893	3	28.1	71.9	40.5	59.5
Average	**16**	**28.4**	**71.5**	**38.1**	**61.9**
SEEDLINGS.					
Crops of 1880–85	7	26.0	74.0	26.0	74.0
Crop of 1891	None.				
Crop of 1892	6	24.0	76.0	37.0	63.0
Average	**13**	**25.0**	**75.0**	**32.5**	**67.5**
MEDITERRANEAN SWEET.					
Crops of 1885–86	3	30.0	70.0	25.0	75.0
Crop of 1891	3	27.0	73.0	33.0	67.0
Crop of 1892	2	30.0	70.0	41.0	59.0
Crop of 1893	2	29.2	70.8	36.8	63.2
Average	**10**	**29.1**	**70.9**	**33.4**	**66.6**
ST. MICHAELS.					
Crops of 1885–86	5	19.0	81.0	23.0	78.0
Crop of 1891	5	19.0	81.0	31.0	69.0
Crop of 1892	2	22.0	78.0	40.0	60.0
Crop of 1893	3	18.2	81.8	37.2	62.8
Average	**15**	**19.5**	**80.5**	**32.8**	**67.2**
MALTA BLOOD.					
Crop of 1885	1	27.0	73.0	30.0	70.0
Crop of 1891	3	31.0	69.0	36.0	64.0
Crop of 1892	None.				
Crop of 1893	2	33.0	67.0	37.5	62.5
Average	**6**	**30.3**	**69.7**	**34.5**	**65.5**
RUBY BLOOD.					
Crop of 1892	2	33.2	66.8	36.7	63.3
Average 1892-93	**3**	**31.8**	**68.2**	**35.7**	**64.3**
KING.					
Crop of 1887	2	23.2	76.8	23.0	77.0
Crop of 1892	1	49.3	50.7	50.0	50.0
Average	**3**	**31.9**	**68.1**	**32.0**	**68.0**
TARDIVE. (Valentia Late.)					
Average 1892-93	**2**	**20.0**	**80.0**	**33.4**	**66.6**

Juiciness, or Proportion of Juice to Flesh.—A comparison of the figures, especially the average, in the large table, shows that, of the named varieties examined, the Navel is the driest, and while the St. Michael and Tardive have the largest proportions of juice, they are closely followed in that respect by the Mediterranean Sweet, Seedlings, and Malta Blood. It is interesting to note that the King orange, one so much admired in Southern California, seems to promise to equal, if not exceed, the St. Michael in juiciness. These facts will be better understood by reference to the table above, which gives the percentage ratios.

Sugar Contents of the Juice.—In the main the highest sugars are seen in that fruit raised in 1892, but the differences are only slight in any variety, so that the averages for this important ingredient of oranges

are hardly changed by the later work accomplished. Our examination of those varieties of oranges not largely grown in this State, as represented by the Jaffa, Star, Parson Brown, Du Roi, and Pineapple, does not seem to show that *they* give promise of developing higher saccharine properties than the others; however, we have seen that the King and Mandarin oranges from southern counties do give such promise.

Average Percentages of Sugar and Acid.

Variety.	No. of Samples.	Sugar.	Acid.
NAVELS.			
Crop of 1885	3	9.89	1.04
Crop of 1891	6	9.92	1.02
Crop of 1892	4	11.57	1.02
Crop of 1893	3	11.47	.79
Average	**16**	**10.46**	**.97**
SEEDLINGS.			
Crop of 1885	5	9.50	.94
Crop of 1891	1	10.09	1.68
Crop of 1892	6	12.63	1.29
Average	**12**	**11.11**	**1.17**
MEDITERRANEAN SWEETS.			
Crop of 1885	1	10.00	1.09
Crop of 1891	3	9.70	1.38
Crop of 1892	2	9.70	1.29
Crop of 1893	2	8.80	1.27
Average	**8**	**9.55**	**1.75**
ST. MICHAELS.			
Crop of 1885	3	9.70	1.14
Crop of 1891	5	8.71	1.15
Crop of 1892	2	10.10	1.21
Crop of 1893	3	9.99	1.14
Average	**13**	**9.65**	**1.16**
MALTA BLOOD.			
Crop of 1885	1		1.43
Crop of 1889	3	10.30	1.61
Crop of 1893	2	9.88	1.19
Average	**6**	**10.10**	**1.41**
RUBY BLOOD.			
Crop of 1893	2	10.12	1.31
Average 1892-93	**3**	**11.08**	**1.51**
KING.			
Crop of 1887	2	13.95	1.32
Crop of 1892	1	11.60	1.84
Average	**3**	**13.17**	**1.49**
TARDIVE (VALENTIA LATE).			
Average 1892-93	**2**	**9.98**	**1.00**

The above table, showing the average percentages of sugar and acid, develops the fact that the several varieties of oranges range in the following order in point of sweetness, or sugar contents: Seedlings, with 11.11 per cent of sugar in juice; Navels, 10.46 per cent; Malta Blood, 10 per cent, and St. Michaels and Mediterranean Sweets, each about 9.60 per cent. Of course, the King and Ruby Blood are not included in the statement, as but comparatively few samples of these varieties have come under our hands. Individual samples, however, form notable exceptions to the above figures, for we find the Seedling, No. 39, from Englewood, Los Angeles County, to have 14.70 per cent sugar (the maximum); the King, No. 45, from Riverside, 14.62 per cent, and the Mandarin, No. 47, from San Gabriel, 13.84 per cent.

Some of the latest crop of Navels show higher figures than the general average (10.46 per cent sugar), No. 75, picked about March 1, 1893, and No. 91, picked in the latter part of April, 1893, both from Riverside and grown on sour stock, carry, on the average, 12 per cent sugar, which figure is not bettered among the usual named Navels. No. 31, "Thomson's Improved Navel," crop of 1892, gave 13.10 per cent sugar. No. 68, from Porterville, gathered on the 1st of March, had quite the average sugar contents for a Navel. With the exception of the Seedling, No. 74, with 10.16 per cent sugar as against 11.11 per cent for the average seedling, we may pass the Mediterranean Sweets, St. Michaels, and Malta Bloods of the crop of 1893, with the remark that they hold their own in respect to sugar.

By reference to the following table, already published in Bulletin No. 102, the relations between the average *sugar* and the average *acid* contents of some California fruits will easily be seen. For convenience of comparison the acid is expressed in terms of sulphuric acid (SO_3).

Percentages of Sugar and Acid.

No. of Analyses.	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid, Per Cent.	Sugars, Per Cent.		
80	Oranges	1.28	10.68	7.12	5.40
4	Figs, White Adriatic	.21	19.70		19.20
37	Other figs	.10 to .20	10 to 29.00		8.0 to 19.20
11	Apricots	.68	13.31	11.93	11.10
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.89
2	Peaches	.24	17.00	13.40	12.50
	Grapes	.50	24.00	23.00	20.70

Acid in the Juice.—Here, again, we are obliged to make the observation that the latest results relating to acidity do not admit of any changes being made upon the *averages* presented in the table for acid contents in the juice of oranges. Taking the acid of the average Seedling (1.20 per cent) then, as a starting point, on account of its very agreeable taste, especially as it is combined with the highest sugar, we may rate the average Navel, with its 1.00 per cent, as rather low in acid, but combined with the second highest sugar; and the average Mediterranean and St. Michael, with about 1.20 per cent, as containing an adequate, pleasant acid, but combined with much less sugar. The Malta and Ruby Bloods, with an average of 1.45 per cent of acid, may be considered high in this respect, in combination, too, with a quantity of sugar that nearly reaches that possessed by the average Navel. Like the Bloods, the King orange stands high in acid and sugar.

In as far as this work has progressed with the next named fruits, we may put the Jaffa, No. 67, with 1.15 per cent, the Star, No. 70, with 1.25 per cent, and the Du Roi, No. 83, with 1.19 per cent, as adequate in acid; and the Tardive, with an average of 1.00 per cent, the Pineapple, No. 84, with 0.64 per cent, and the Parson Brown, No. 82, with 0.78 per cent, as low in acid; all, too, in combination with only moderate amounts of *sugar.* Still very much lower than these varieties, as previously reported,

stands the Mandarin, No. 47, with only 0.36 per cent acid (the lowest of all), but the sugar of this variety rates among the very highest.

The results obtained for each of the well-known or largely grown varieties for the fruit of crop of 1893, are almost the average for all. The exceptions worthy of notice are the Navels, Nos. 75, 91, and 68, with about 0.80 per cent of acid, Malta Blood, No. 73, with 1.02 per cent, and Ruby Blood, No. 69, with 1.17 per cent of acid. The exceptions to the general averages are yet thus found in the earlier crops, for the Malta Blood, No. 18 (1891), with 2.04 per cent, still leads in acid contents; the Ruby Blood, No. 43 (1892), from Nordhoff, with 1.92 per cent; the Riverside King, No. 46 (1892), with 1.84 per cent, and the Seedling, No. 36 (1892), from Tulare, with 1.71 per cent, being the only ones which run anywhere near it. The next highest acids are found in samples of Mediterranean Sweet, No. 41 (1892), from Porterville, with 1.67 per cent; Seedling, No. 33 (1892), from Smartsville, with 1.64 per cent, and St. Michaels, No. 42 (1892), with 1.55 per cent—figures which indicate that these varieties stand in about the same relation to each other in acid contents as they did the previous year (1891); however, those of the crop of 1892 present, on the whole, somewhat the widest range in this respect.

Nutritive Values—Nitrogen Contents.—Passing the discussion of the relative importance that the flesh-forming ingredients (albuminoids) hold in these and among other fruits, for the reason that this matter has heretofore received at our hands much attention and space, we can turn with profit to the question of the distribution of nitrogenous matters in the parts—flesh and rind—of some of our oranges. Basing our calculations upon the whole fruit, we see, in the large table, that, contrary to our earlier conclusions (Bulletin No. 93), the nitrogen in the rind, representing the waste as far as food value is concerned, seems to amount to more than it was there credited. For the rind of the largely grown varieties of oranges contains from one third to one half the total nitrogen, excepting in one instance, St. Michaels (No. 71), where we find it to be as low as one fifth the total. In the rind, too, we notice much more variable results in nitrogen contents than for this ingredient of the flesh, even for the same varieties: witness the Navels, Mediterranean Sweets, and St. Michaels of the crop of 1893.

The *total nitrogen*, then, remaining nearly constant for all the largely grown varieties, averaging about 0.18 per cent, we find the flesh, with an average of 0.12 per cent of nitrogen, holds about *two thirds* of the nitrogen; this represents the available part.

From Bulletin No. 101, page 7, it appears that the waste nitrogenous matter, *i. e.*, that part contained in the shells of the prunes and apricots grown here (like that of the rind of the orange), shows the greatest variation of results: the flesh of prunes and apricots contains a pretty uniform amount of nitrogen.

Under the heading "whole fruit" in the large table is given the percentages of albuminoids contained in the flesh of fresh fruit, or that part available for food; also, for the sake of those interested, the nitrogen contained in the fresh flesh and fresh rind is tabulated under the headings "flesh" and "rind."

To save cross-reference we put here in tabular form the average per-

centages of albuminoids contained in different fruits examined at this Station and already reported in Bulletin No. 101.

Average Percentages of Albuminoids.

Fruits.	Number of Analyses.	In Whole Fruit—Total.	Calculated upon Whole Fresh Fruit.	
			In the Fresh Flesh, or Edible Portion.	In Fresh Pits, or Rinds.
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Plums.				
California	3	1.130	1.000	.130
European		.400		
Apples and Pears.				
European		.375		
Figs.				
California	28	1.522	(1.522)	
European (Smyrna)		1.420		
Nectarines		.731	.625	.106

So far, then, the fig rates *first* in flesh-forming ingredients, with little choice between the apricots and plums for *second;* and for third place the prunes and oranges run nearly even.

LEMONS.

Description of Lemons Received (Season of 1892-93).

(For description of lemons received from the crop of 1891, see Agricultural Report for 1890, page 109; for those of crop of 1892, see same report for years 1891–92, pages 102 and 103.)

No. 90. *Eureka*, from Ontario, San Bernardino County. The samples were grown by J. W. Freeman, and are from the exhibit at the State Fair at Colton. They were picked in November, 1892, and received for analysis March 27, 1893. Their skin was of bright yellow color, and of medium thickness; the base fleshy, and apex sharply pointed. They had a tender flesh, and were without seeds.

No. 88. *Lisbon*, from Ontario, San Bernardino County. The sample was taken from the State Fair exhibit at Colton, and was grown by J. W. Freeman. They were picked in November, 1892, and received here on March 27, 1893. The fruit had a clean, smooth, and bright yellow skin, with slightly flattened base and pointed apex; the skin was slightly ribbed. The flesh was tender, and had very few seeds.

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nearly so acid as that of Royal Messina (No. 85), but similar to that of Villa Franca (No. 87) from Ontario.

No. 87. *Villa Franca*, from Ontario, San Bernardino County. Grown by J. W. Freeman. The sample is from the lot of "cured lemons" that was awarded the first premium at the State Fair at Colton. They were picked on January 15, 1893, and received here for examination March 27, 1893. These samples of lemons were the brightest, cleanest, and smoothest skinned of any yet examined from the crops of 1891, 1892, and 1893. The apex and base were both very fleshy; the pulp very tender, and seeds few but well developed.

No. 64. "*Marysville Seedling.*" Grown by A. J. Binney. The samples were picked on December 5, 1892, and cured by C. H. Shinn. They were analyzed on March 2, 1893; they were at that time somewhat shriveled and soft.

No. 65. "*Marysville Seedling.*" Grown by Mr. Dougal. The samples were picked December 5, 1892, and cured by C. H. Shinn. They were received for analysis on March 2, 1893, in a fair, rather soft condition.

No. 66. "*Marysville Seedling.*" Grown by Mrs. Karr. The samples were picked on December 5, 1892, and cured by C. H. Shinn. They were received for analysis on March 2, 1893, in good condition, but not very firm.

Discussion of Analytical Results.

Except for the reports upon some of the new varieties in our hands, the results found below for the crop of 1893 do not present any real differences in percentages of rind, pulp, and acid from those reported for the crops of 1891 and 1892. (See Agricultural Report for years 1891–92, page 112.)

The Rind.—On the whole the varieties examined (nine samples) for the crop of 1893 show the most constant returns in rind contents, averaging but 24.8 per cent; those of the crops of 1891 and 1892 show for the

European		.400		
Apples and Pears.				
European		.375		
Figs.				
California	28	1.522	(1.522)	
European (Smyrna)		1.420		
Nectarines		.731	.625	.106

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No. 89. *Genoa*, from Ontario, San Bernardino County. The sample was taken from the State Fair at Colton; grown by J. W. Freeman. They were gathered in November, 1892, and received here on March 27, 1893. The skin was clean and yellow colored; the "rag" thickish; the base fleshy, and the apex pointed. The flesh was tender, and had no seeds.

No. 85. *Royal Messina*, from Nordhoff, Ventura County; grown by J. B. Wickoff. This orange was awarded a special first premium at the State Fair at Colton. The samples were raised on sour orange stock; they were gathered in November, 1892, and received here for analysis on March 27, 1893. The fruit was quite large, slightly ribbed, with apex and base medium fleshy; the skin was smooth, and bright yellow in color, and with a thin "rag." The flesh was seedless and rather tough; the juice intensely acid. Mr. J. E. Cutter states that "this fruit is from young trees, which he describes as the handsomest lemon trees he has seen, strong of growth, and nearly thornless."

No. 86. *Villa Franca*, from South Riverside. Grown by Dr. R. D. Barber. The samples were taken from the exhibit at the State Fair at Colton. They were raised on sour orange stock, picked in November, 1892, and received here for analysis March 27, 1893. The fruit was of a deep bright yellow color, slightly ribbed, the base and apex not fleshy; the pulp was tough; the seeds few and undeveloped. The juice was not nearly so acid as that of Royal Messina (No. 85), but similar to that of Villa Franca (No. 87) from Ontario.

No. 87. *Villa Franca*, from Ontario, San Bernardino County. Grown by J. W. Freeman. The sample is from the lot of "cured lemons" that was awarded the first premium at the State Fair at Colton. They were picked on January 15, 1893, and received here for examination March 27, 1893. These samples of lemons were the brightest, cleanest, and smoothest skinned of any yet examined from the crops of 1891, 1892, and 1893. The apex and base were both very fleshy; the pulp very tender, and seeds few but well developed.

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No. 66. "*Marysville Seedling.*" Grown by Mrs. Karr. The samples were picked on December 5, 1892, and cured by C. H. Shinn. They were received for analysis on March 2, 1893, in good condition, but not very firm.

Discussion of Analytical Results.

Except for the reports upon some of the new varieties in our hands, the results found below for the crop of 1893 do not present any real differences in percentages of rind, pulp, and acid from those reported for the crops of 1891 and 1892. (See Agricultural Report for years 1891–92, page 112.)

The Rind.—On the whole the varieties examined (nine samples) for the crop of 1893 show the most constant returns in rind contents, averaging but 24.8 per cent; those of the crops of 1891 and 1892 show for the

average, respectively, 33.7 and 31.6 per cent of rind. The range for the latest crop was between 19.1 per cent rind, found in Villa Franca, No. 86, from Riverside, and 29.6 per cent, in Lisbon, No. 83, from Ontario; while for the 1892 fruit we have noted differences which show that from one fifth to one half the whole fruit was skin; likewise, the 1891 fruit varied in this respect from one quarter to two fifths of the whole fruit for the rind. The minimum of 19.1 and 19.3 per cent of rind is found, respectively; in the Villa Franca, No. 86, and the Lisbon, No. 52 (Tulare, of 1892), among the named varieties; the maximum, as yet found, 49.8 per cent, still remains with the Seedless, No. 58, from Azusa.

The Pressed Pulp.—The results as given in the averages for all the crops systematically studied are strikingly alike, all being upwards of 25 per cent. The fruit of 1892 shows the widest variation among the named varieties; viz., from 20 to 35 per cent of pulp. After removing the juice we have then for the waste part of our lemons 55 per cent, made up of the rind, 29.2 per cent, and of dry pulp, 25.5 per cent.

The Acid.—The fruit of the crop of 1893 shows the highest acid on the average, and, too, the maximum acid percentage for a single lemon thus far obtained among all here examined, viz., 8.40 per cent in the juice of the Royal Messina, No. 85, from Nordhoff. This figure is very nearly approached, however, by that given for the Eureka, No. 48, from Nordhoff (crop of 1892), namely, 8.33 per cent. Other high acid percentages have been reported, the Eureka, No. 49, from Englewood, yielded 8.14, and Seedling, No. 64, from Marysville, gave 8.12 per cent acid. The minimum acid is found in Seedless, No. 58, from Azusa.

ANALYSES OF CITRUS FRUITS (CROP OF 1893-4) FROM THE SOUTHERN CALIFORNIA MIDWINTER FAIR ASSOCIATION EXHIBIT, SAN FRANCISCO, CAL.

The fruits here reported upon—twelve samples of oranges, nine samples of lemons, and one sample of pomelo, or grape-fruit—were sent for examination by Frank Wiggins, Esq., Superintendent of Southern California Midwinter Fair Association, Midwinter Fair, San Francisco, Cal.

ORANGES.

No. 102. *Navel*, from Duarte, Los Angeles. Grown by A. C. Thomson, and named Washington Navel by sender. The grower calls it "Improved Navel." The sample was received March 12, 1894, in but fair condition, as it was rather soft. Its rind was thick and "corky"; flesh was "mushy," but quite juicy and tart to the taste.

No. 114. *Navel*, from same place and grower as sample No. 102, but picked about June 1, 1894; not exhibited. Fruit was in good condition when received (June 14, 1894), and varied in size and shape, some being large, others only medium in size; some well rounded, others markedly elongated. The rind was quite thick, brittle, and easily separated from flesh. Flesh rather coarse-textured, but very sweet. Mr. Thomson calls this lot his "Improved Navel." Under No. 31, crop of 1892, another analysis is given of this "Improved Navel."

No. 110. *Navel*, from Pasadena. Grown by L. S. Porter, and received here on March 27, 1894. The samples were large but thin skinned, of

coarse texture, and rather tough flesh; juice very acid for a Navel orange.

No. 100. *Mediterranean Sweet*, from Duarte. Grown by John Scott, and received here on March 12, 1894. A round-shaped, deep yellow-colored fruit, with a brittle but not very thick rind, which was easily removed from the flesh. Its flesh was somewhat coarse, but tender and juicy. Seeds well developed.

No. 101. *St. Michael*, from Duarte. Grown by John Scott, and received here on March 12, 1894. Fruit was round in shape, very large, and of bright lemon-yellow color. Skin rather thin, and separated easily from the flesh. Seeds well developed.

No. 109. *St. Michael*, from Porterville, Tulare County. Grown by G. F. Frost, and received here on March 12, 1894. A good typical sample of the variety, with very firm flesh and well-developed seeds.

No. 103. *Malta Blood*, from Duarte. Grown by M. D. Johnson, and received here on March 12, 1894. Color yellow to red-yellow, with reddish spots; shape tends to be elongated; skin rather thick; flesh marked with characteristic streaks.

No. 107. *Malta Blood*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. Some of the fruit was round in shape, others elongated, and all had thick skins; no seeds.

No. 108. *Ruby Blood*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. Fruit and flesh colored deep red, juice wine red; skin and "rag" quite thick; flesh loose-textured; seeds round in shape and flattened.

No. 99. *Tardive* (*Valentia Late*), from Duarte. Grown by John Scott. Fruit globular shaped, quite unlike some former samples (No. 92), which were elongated. This sample had a brilliant yellow-colored, thin skin (quite as thin as that of a typical paper-rind St. Michael), which easily separated from the flesh. Its seeds were well developed, and the flesh was tender, delicate, and melting.

No. 106. *Jaffa*, from Porterville. Grown by G. F. Frost, and received March 12, 1894. A bright-colored, clean fruit, with medium thick "rag" and skin; seeds small but perfect; juice sweet and quite tart.

No. 105. *King*, from Riverside. Grown by J. E. Cutter, and received for examination on March 12, 1894. Fruit larger than some of the earlier samples examined here (Nos. 44 and 45), but characteristic as to shape and rough appearance.

LEMONS.

No. 97. *Eureka*, from Ontario, San Bernardino County. Grown by J. W. Freeman. This fruit was firm, and its skin and "rag" thick and solid; its flesh was tender, fairly juicy, and contained no seeds.

No. 112. *Eureka*, from San Diego. Grown by F. O. Wadsworth. This fruit was slightly above the usual size, and had a thick, heavy skin and "rag"; firm flesh and few long and pointed but poorly developed seeds.

No. 96. *Lisbon*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. The fruit was variable in shape; quite firm; skin and "rag" thick; flesh tender and juicy; seeds few and undeveloped.

No. 98. *Genoa*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. A firm fruit, with thick skin and "rag," and tender flesh.

No. 95. *Villa Franca*, from Ontario. Grown by J. W. Freeman, and received March 12, 1894. This fruit was firm, strongly apiculate, bright colored, and tending to be ribbed. Its skin and "rag" were thick, and it had a flesh of fine texture; was fairly juicy, and had but few seeds.

No. 113. *Villa Franca*, from San Diego. Grown by S. M. Marshall, and received March 27, 1894. A fairly sized sample, with short, oval, pointed apex and base; heavy, thick skin and "rag," and few well-developed seeds.

No. 94. *Villa Franca*, from San Diego. Grown by the San Diego Land and Town Company, and received for analysis on March 12, 1894. This fruit was very large for the kind, rounded in shape, and had a flat base and rather blunt apex. Its skin and "rag" were rather thick; the flesh was coarse-textured and hollow in center; seeds few in number and abortive.

No. 93. *Villa Franca*, from Porterville. Grown by R. Lindner, and received March 12, 1894. Sample was rather small and soft, and showed upon its thin skin some appearance of coast scale. Its stalk end was somewhat pointed, apex was apiculated. The flesh was tender and contained some fairly developed seeds.

No. 111. *Bonnie Brae*, from San Diego. Grown by J. S. Harvey, and received here on March 27, 1894. A bright-colored, egg-shaped fruit, with a very thin skin, which parted easily from the flesh. The flesh segments showed plainly through the skin, but the fruit could not be called ribbed. The flesh was "mushy" and without any seeds.

Partial Analyses of Oranges and Lemons (Crop of 1894) from the Midwinter Fair, Southern California Citrus Exhibit.

Number	Variety.	Place of Production.	Grower.	Date of Reception and Analysis.	Physical Analysis.					Analysis of Juice.			
					Average Weight, in Grams*	Rind	Pulp Pressed	Seeds	Juice, in cem.†	Solid Contents by Spindle	Total Sugars (Inversion)	Cane Sugar (polariscope)	Acid, Citric
	Oranges.												
102	Washington Navel	Duarte	A. C. Thomson	March 12, 1894	184	30.3	34.8		69	13.01	11.00		1.40
114	Washington Navel	Duarte	A. C. Thomson	June 14, 1894	260	27.3	36.3		92	15.20	12.55		0.71
110	Washington Navel	Pasadena	L. S. Porter	March 12, 1894	307	18.6	41.0		100	13.80	11.50		1.68
100	Mediterranean Sweet	Duarte	John Scott	March 12, 1894	210	22.5	30.9		95	11.40	9.65		1.28
101	St. Michaels	Duarte	John Scott	March 12, 1894	167	13.5	28.1	2.1	75	12.40	10.30		1.22
109	St. Michaels	Porterville	G. F. Frost	March 12, 1894	116	19.3	30.0	1.0	51	13.55	10.82		1.30
103	Malta Blood	Duarte	M. D. Johnson	March 12, 1894	170	33.3	30.0		50	12.80	9.80		1.50
107	Malta Blood	Porterville	G. F. Frost	March 12, 1894	150	30.0	26.0		62	13.10	10.60		1.40
108	Ruby Blood	Porterville	G. F. Frost	March 12, 1894	140	37.0	27.0	1.2	43	13.90	10.80		1.50
99	Tardive (Valentia Late)	Duarte	John Scott	March 12, 1894	150	15.2	29.8	1.1	70	13.50	11.00		1.27
106	Jaffa	Porterville	G. F. Frost	March 12, 1894	147	27.2	29.8	0.7	58	13.20	10.80		1.61
105	King	Riverside	J. E. Cutter	March 12, 1894	136	45.7	19.2	2.7	36	14.70	11.70		2.20
	Lemons.												
97	Eureka	Ontario	J. W. Freeman	March 12, 1894	110	44.1	13.5		42	10.00	1.80		6.96
112	Eureka	San Diego	F. O. Wadsworth	March 27, 1894	118	38.8	30.0		37	12.40	3.46		7.77
96	Lisbon	Ontario	J. W. Freeman	March 12, 1894	108	33.3	24.2		40	10.20	2.16		7.00
98	Genoa	Ontario	J. W. Freeman	March 12, 1894	112	44.1	23.5		36	10.70	2.20		7.68
95	Villa Franca	Ontario	J. W. Freeman	March 12, 1894	110	40.6	20.3		39	10.50	1.87		8.01
113	Villa Franca	San Diego	S. M. Marshall	March 27, 1894	103	38.6	26.6	2.5	33	11.40	2.80		8.05
94	Villa Franca	San Diego	San Diego Land and Town Company	March 12, 1894	150	35.5	30.0		40	10.70	2.30		7.91
93	Villa Franca	Porterville	R. Lindner	March 12, 1894	94	28.0	28.0		50	11.80	2.66		7.84
111	Bonnie Brae	San Diego	J. S. Harvey	March 12, 1894	122.5	12.7	37.7		56	8.50	2.20		5.74
104	*Pomelo, or "Grape-Fruit"*	Duarte	F. M. Douglass	March 12, 1894	357	23.5	37.0	3.7	95	13.20	9.50	5.00	2.70

*Thirty grams are equivalent to one ounce. †Thirty cubic centimeters are equivalent to one fluid ounce.

A few words of comparison upon these results, and those of earlier crop fruits, from the same and different localities, is necessary in order to bring out more definitely what is indicated by the above figures.

Comparison of Average Weights.—Oranges: From a comparison of Table A (analyses of California orange crops of 1891, 1892, and 1893), p. 242 of this report, with the figures given just above, it seems that most of the varieties of oranges from the exhibit at the Midwinter Fair weigh *less* than the earlier fruits; for we note that of the eight varieties examined, the Navels, Malta and Ruby Bloods, Tardive, and Jaffa oranges range *less* in weight, while Mediterranean Sweet, St. Michael, and King varieties are nearly the average in this respect. Jaffa, No. 106, from Porterville, and Tardive, No. 99, from Duarte, vary the most of all. The effect of season has doubtless much to do with some of these variations. *Lemons:* Most of the varieties of lemons from the exhibit do not show much difference in weight from those examined in previous years. (See also Table B, analyses of California lemons, crops of 1891, 1892, and 1893, p. 249 of this report.) Villa Franca, No. 94, from San Diego, from the exhibit, was the only remarkably large sample, as compared with the other Villa Francas, and the majority of all the lemons examined, standing as it does in weight about as one and one half to one, or 150 grams (5 ozs.) to 108 grams (3 ozs.) for the average weight. We have, however, found some earlier samples of unnamed varieties of lemons equal to it in weight, and even heavier.

Comparison of Rind Percentages.—Oranges: The rind percentage of the Navels from the exhibit is about the average, except that of No. 114 (18.6 per cent), which, while 10 per cent below the average, is still higher than that we have reported for a sample, No. 4, from Riverside, with 17.5 per cent. The averages referred to are found on p. 244 of this report. The Mediterranean Sweet and Tardive (Valencia Late) from the exhibit yield lower rind percentages than that given for the averages, respectively 7 and 5 per cent less. The Jaffa and Malta Blood are nearly the average, while the Ruby Blood is some 5 per cent higher than the average for that variety in rind. The King orange, with nearly 46 per cent of rind, still does not come up to that of the sample from the same locality, of the crop of 1892, with its 49 per cent rind. *Lemons:* When we compare the figures for rind contents of the exhibited fruits with those upon p. 249 of this report, it is evident immediately that the exhibited lemons run notably higher in rind than the earlier crop lemons, even where they come from the same locality and the same grower. Bonnie Brae, No. 111, from Duarte, presents a very low figure, 12.7 per cent, for skin, which we are not accustomed to see in lemons, although an earlier analysis of Bonnie Brae from San Diego shows 15 per cent rind. The objection to this variety of lemon is, as has been said before in the Agricultural Report for 1882, that its acid is over 2 per cent less than the average.

Sugar Contents of the Juice.—Oranges and Lemons: The amount of sugar in the juice of the exhibited fruits compares, on the whole, favorably with the figures for that (averages) on page 245. For the Navels (leaving out No. 114, on account of its late gathering), we find a difference of from a half to one per cent more sugar in the last fruit examined; the juices, too, of the St. Michaels, Malta Blood, and Tardive are a little sweeter (by analysis) than the earlier fruits. The King and Malta Blood, however, do not reach in saccharine contents within one per cent

of the averages for these varieties. The Tardive, No. 99, contains about one per cent more sugar than the 1892–93 fruits of the same name. The lemons from the exhibit show some variation in sugars from those previously examined, though not enough to make it profitable to extend the comparison here.

Acid in the Juice.—Oranges: The Navels (excepting No. 114, picked in June, 1894), Jaffa, Tardive, and King oranges from the exhibit yield nearly half as much again acid as do the fruits averaged and tabulated on page 245 of this report. Those varieties showing similarity with the averages for acid contents are the Mediterranean Sweet, St. Michaels, and Malta and Ruby Bloods. The "Improved Navel" from Duarte, represented by Nos. 31 (Agr. Rept. for 1891–92, p. 100, and table on p. 104), 102, and 114, is a very remarkable orange, in that it is capable of being gathered from December to the following June, and at the same time yield such desirable combinations of sugars and acids. No. 114, picked in June, contains 12.55 per cent sugar—2 per cent above the average for Navels—with 0.71 per cent acid, the least figure yet returned for this ingredient—0.25 per cent less than the average. No. 31, gathered in March, has an even higher saccharine content, 13.10 per cent, together with 1.20 per cent acid, and indicates a better balanced fruit. No. 102, picked for the Midwinter Fair exhibit, and received here in March, yields a high sugar, 11 per cent, as well as a high acid, 1.40 per cent. These facts when considered with those given above, in the description, relating to size, appearance, medium rind, palatableness, etc., recommend this fruit to the careful attention of growers and consumers. *Lemons:* Aside from the Bonnie Brae, No. 111, it is safe to say that the exhibited lemons compare favorably with the earlier ones in regard to their acidity, ranging very close to the average, *i. e.*, upwards of 7.5 per cent; still none of them reach the figure of 8.40 per cent acid, found in Royal Messina, No. 85, from Nordhoff.

POMELO, OR "GRAPE-FRUIT."

No. 104. Sample grown by F. M. Douglass, of Duarte, and received on March 12, 1894. The fruit was nearly round in shape; skin varied from light to deep lemon-yellow in color; "rag" abundant. Its flesh was lemon colored, rather "mushy," but juicy; flavor of juice, "bitter-sweet." Seeds were numerous, large, flat, and rugose.

Only one other sample of this fruit, a pear-shaped one, from Oroville, has been previously analyzed and reported upon at this Station (Agr. Report for 1887, p. 76). We give the analysis here again, with that of the Midwinter Fair sample described just above.

Analyses of Pomelo, or "Grape-Fruit."

	Pear-Shaped Pomelo.	Round-Shaped Pomelo.
Date of receipt and analysis	January, 1886	March 12, 1894
Physical Analysis—		
Average weight, in grams	344.00	357.00
Rind, per cent	33.00	23.50
Pulp, pressed, per cent	15.00	37.00
Seeds, per cent	5.00	3.70
Juice, in ccm	143.00	95.00
Analysis of Juice—		
Solid contents by spindle, per cent	9.49	13.20
Total sugars, per cent	----------	9.50
Cane sugar, per cent	----------	5.00
Acid, citric, per cent	1.92	2.70

(These specimens show too high an acid percentage to make them agreeable to most tastes. Pomelo varieties are now becoming very popular at the East, and Florida growers are said to find the production quite profitable. Selected seedlings are being propagated because of superiority in thinness of skin and reduction of the acridity and acidity of the juice. Probably California must advance in the same manner in the development of better pomelos, if the fruit is to become popular for local use or for Eastern shipment. E. J. W.)

Note.—Very lately we have received from Japan an interesting report by Prof. M. Fesca, of the Imperial Geological Institute, in which the Agricultural Experiment Station of *Komaba* furnishes some analyses of Japanese grown oranges. The results are reported upon the whole fruit and we have, in part, rearranged them for comparison with figures which this Station gives for our oranges.

Japanese Oranges.

Name of Variety.	Unshiu.	Kishiu.
Water, per cent	84.20	85.10
Organic matter, per cent	13.01	11.71
Ash, per cent	2.79	3.19
Totals	100.00	100.00
Nitrogen, whole fruit, per cent	.18	.16
Albuminoids corresponding to nitrogen, per cent	1.12	.68
Percentage Composition of the Ash.		
Potash	44.44	42.63
Soda	10.04	7.83
Lime	21.11	22.57
Magnesia	8.58	6.58
Peroxid of iron (not reported)	----------	----------
Br. oxid of manganese (not reported)	----------	----------
Phosphoric acid	10.40	16.00
Sulphuric acid	3.65	3.10
Silica	.70	.66
Chlorine (not reported)	----------	----------
Totals	98.92	99.37

EXAMINATION OF CALIFORNIA PRUNES, APRICOTS, PLUMS, AND NECTARINES.

By Geo. E. Colby.

(*Experiment Station Bulletin No. 101.*)

Note.—For the purposes of this discussion a distinction is made between plums and prunes, as is common in the horticultural literature of this State. By the term "prune" is signified a plum which dries successfully, without removal of the pit, and produces a sweet dried fruit, though in the confusion of our nomenclature, not even this broad classification is faithfully followed. For example, we have the "Hungarian prune" as a local traditional name for Pond's Seedling plum, which has no value as a prune; and we have also Coe's Golden Drop plum, which does answer the requirements for a dried prune, and in that form is marketed as a prune, and sometimes given fancy names by packers. We do not, however, in this publication, attempt to correct the classification, but follow the popular arrangement.

The order of enumeration of fruits in the head line above, and in the tabular statements which follow, is based upon the relative commercial importance of the fruits in this State. An arrangement of the chief table of analyses is also made to bring into juxtaposition the varieties from adjacent regions of the State that effects of local climates and soils upon the same variety may be disclosed if such exist. As this is only the beginning of such investigation, the results in this regard should be looked upon as tentative. Many more analyses are required to demonstrate constant differences of this nature, and we invite the sending of representative samples of named varieties from all parts of the State. It is well to send about ten pounds of each variety, each specimen being wrapped to prevent bruising. Such samples may be sent by express at our expense. Each shipment should be accompanied by a letter, giving name of variety, age of tree, and stock upon which it is budded or grafted, location of orchard, and name of grower; also notes of culture, irrigation, etc. Address such shipments to "Agricultural Experiment Station, University of California, Berkeley, Cal."

This bulletin is a continuation of the work reported in Bulletin 97 of this Station, and in some paragraphs the text is reproduced, only changing figures to include the results of a greater number of analyses. It is perhaps only fair to Mr. Colby to state that the analyses of the fruit grown in 1892 are his personal work, and have been made without assistance. (E. J. Wickson.)

The subjects discussed in this paper are summarily set forth in the following quotation from Bulletin No. 93 of this department:

The purpose of this work is to show comprehensively the proximate and ash composition of the leading varieties of fruit as grown in the principal fruit regions; and, inferentially, the influence exercised upon them by the prominent conditions of soil, climate, fertilizers, etc. The physical data (proportion of pits to flesh, etc.) are of interest from a commercial standpoint, as showing what is being purchased as to available and waste material, etc.

The consumer, though usually considering fruit as a luxury, would derive much valuable knowledge from studying the fruits in their relative values as foods. The nourishing portions, shown especially by the nitrogenous and saccharine contents, vary greatly with the variety and conditions of growth. It is not, then, a matter of indifference to the consumer what fruit he uses, but an important question of domestic economy.

The ash ingredients, together with the nitrogen contents of the standard varieties, are of high interest in connection with vital questions of soil exhaustion and fertilization. The soil ingredients extracted by an ordinary crop are a serious drain upon the supporting soil, and the lines of heaviest draft can only become known by the actual determination of the constituents withdrawn.

Description of Prunes, Apricots, and Plums Received in 1892.

(For a description of these fruits received and analyzed in 1891, see Bulletin No. 97, of this Station.)

PRUNES.

No. 31. *French*, from Auburn, Placer County. The sample was grown by Young Bros., and received in good condition on October 7, 1892. It was large in size and with a very sweet taste; its flesh firm and juicy.

"The soil is red slate, well drained, with a southern exposure; very little irrigation used."

No. 32. *French*, from Newcastle, Placer County. The sample was grown by E. B. Silva, and received September 23d in a somewhat poor condition, the fruit being a little shriveled and very ripe. It was small in size, its flesh rather juicy and very sweet.

No. 33. *French*, from Yuba City, Sutter County. The sample was grown by R. C. Kells, and received on September 27th in a fair condition, but very ripe. "The soil is a sandy loam, dark gray or light brown in color, with a dark clay subsoil. The ranch is about three quarters of a mile from the west bank of the Feather River, and has good drainage. The trees are eight years old, on peach root."

Nos. 34, 35, and 36. *French*, from Campbell, Santa Clara County. Grown by Campbell Fruit Growers' Union. No. 34 was received on September 1st in only fair condition, the fruit being slightly shriveled; the trees have not been irrigated; its size was very large and taste very sweet, though the flesh was not as firm as No. 35. No. 35 was received in good condition on September 1st; trees have been winter irrigated; fruit full-fleshed, oversized, well rounded, and with a firm and tender flesh, more juicy than No. 34. No. 36 was received on September 21st in fair condition, the fruit being slightly shriveled, very ripe, and not as large as the other two; its flesh, like that of No. 34, was rather coarse in texture, and not as juicy or tender as that of No. 35. F. M. Righter, Vice-President of the Campbell Fruit Growers' Union, writes: "There is a great variety of soil in this valley; it is generally a gravelly loam—a sediment deposited by the Los Gatos Creek—and upon this the prunes were grown. This soil is very porous, trees cannot be injured by water during winter;—have had several feet of water around some of my trees as late as June without injuring them. The soil varies in depth from 10 to 18 feet; in some places the soil to the depth of 4 or 5 feet is very sandy, below that there is more clay."

Nos. 40 and 41. *French*, from Ventura, Ventura County. Grown by J. W. Anderson, and received on September 5th. No. 40 is of the usual size, with firm flesh, rather juicy, and sweet. No. 41 was below the usual size and had large pits. "These prunes are from a mountain-valley orchard two and one half miles from the sea, and at an elevation of 700 feet; mountains 2,000 feet high lie between the valley and the ocean. The largest of the prunes, No. 40, was raised on a sandy soil; the others on heavier soils."

No. 42. *French*, from Pomona, Los Angeles County. The sample was grown by P. M. Doyle, and received on September 6th in good condition. It was of usual size, with hard and juicy fruit, but not very sweet. Mr. John S. Calkins, who procured this sample for the Station, writes: "These prunes are from an orchard seven years old, growing on a sandy loam soil and situated one and one half miles northeast of Pomona, on the Kingsley tract. The trees bore a good crop last year and are very full this year."

No. 44. *French*, from near Pomona, Los Angeles County. The samples were grown by J. W. Lawson, and received in good condition on September 20th. Their flesh was tender and juicy. "The orchard is situated two miles north of the Chino Experiment Station, at an elevation of from 300 to 400 feet above the sea. The soil is a sandy loam. *The trees* are five years old, and irrigation has been resorted to once a

month during the dry season. The ground has been fertilized but once, and then only stable manure was used."

No. 37. *Robe de Sergent*, from San José, Santa Clara County. The sample was grown by John Rock, and received in good condition on August 25th. It was fully ripe and more juicy than No. 5 of the crop of 1891. The flesh was also tender and sweeter than the latter.

No. 38. *Fellenberg*, from San José, Santa Clara County. The sample was grown by John Rock, and received in good condition on August 25th. It was fully ripe, with a hard and juicy flesh and only moderately sweet.

No. 39. *Bulgarian*, from San José, Santa Clara County. This was also grown by John Rock, and received on September 30th in rather poor condition, overripe, and shriveled. It was examined for comparison of its sugar contents with that of No. 8, the same variety, of the crop of 1891.

Of samples Nos. 37, 38, 39, Mr. Rock says: "Last season (1891) they were all overbearing and lacked flavor; this year (1892) the crop is light and the fruit better. The land on which the prunes were grown is a sandy alluvial soil, made by deposits from Coyote Creek.. These deposits are from 4 to 6 feet deep, under which lies a stratum of 3 to 4 feet of loam, and under this a sandy layer lighter than the surface soil. During the summer the ground water is from 14 to 18 feet below the surface."

PLUMS.

No. 45. *Coe's Golden Drop*, from Auburn, Placer County. Grown by Young Bros., and received in good condition on October 7th. The sample was somewhat larger than that from Marysville (No. 46). The flesh was not as firm nor as juicy as the French prunes.

No. 46. *Coe's Golden Drop*, from Marysville, Yuba County. The sample was grown by Dr. S. Jewett, and received in excellent condition on August 30th. The flesh was firm and juicy.

No. 47. *Yellow Egg*, from Marysville, Yuba County. The sample was grown by Dr. S. Jewett, and received in very good condition on August 30th. The flesh was firm and more juicy than that of the plums just mentioned. Both of the samples from Marysville were from trees six years old growing on a heavy sandy loam soil with clay subsoil.

APRICOTS.

No. 25. *Royal*, from Concord, Contra Costa County. The sample was grown by J. T. Sutton, and received in good condition on August 1st. It was taken from trees three years old and was very large and fully ripe.

No. 26. *Royal*, from Oleander, Fresno County. The sample was grown by J. H. Harding, and received on June 24th, in excellent condition. It was under the usual size, the flesh quite juicy, but not very sweet, and with a peachy flavor. "This year my trees are so heavily loaded that the fruit is very small; the trees have not had any irrigation for two years; age of trees, nine years; have made only medium growth, and have borne very heavily for five years. Soil sandy, slightly tending to white ash, sub-water-level 10 feet below surface."

No. 27. *Royal*, from Santa Maria, San Luis Obispo County. It was grown by L. E. Blochman, and received on August 10th in good condition, quite ripe, and with high color. It was of the usual size and with a firm and rather juicy flesh.

No. 28. *Royal*, from North Pomona, Los Angeles County. It was grown by Mrs. J. L. Loomis, and received on July 2d, in an excellent condition, fully ripe and quite large and with tender and very juicy flesh. Mr. J. S. Calkins, who obtained the samples for the Station, writes: "Trees seven years old, in gravelly loam soil, irrigated once this year. The location is about three miles south of the foothills of the Sierra Madre Mountains."

No. 29. *Hemskirk*, from Oleander, Fresno County. It was grown by A. Allison, and received on June 25th in good condition; its flesh was firm and juicy. "The trees are nine years old, and heavy, regular bearers. The soil is of the white ash variety, with the water-level 7½ feet below the surface."

No. 30. *Moorpark*, from Oleander, Fresno County. The sample was grown by J. H. Harding, and received in very good condition on June 25th. It was of a light color. "The soil is sandy. The trees are nine years old, and have not been irrigated. The water-level is at 10 feet from the surface."

NECTARINES.

No. 48. "*The New White*," from Yuba City, Sutter County. It was grown by H. P. Stabler, and received on September 1st in excellent condition. It was light-colored and very large in size, very juicy, and pleasantly tart to the taste. The flesh was very delicate.

Results of Analyses.

The table given below shows the results of the analytical work for the seasons 1891 and 1892, that of 1892 covering a greater area of the State than that of 1891, which dealt mostly with Santa Clara Valley fruits. Subdivision A gives the physical and general proximate analyses, and under this head we have added to that of the previous season, the separation of the pit into its component parts—shells and kernels—and reported upon the nitrogen contents of these separate parts. Subdivision B gives the results of the complete analysis of the ash, in which we have considerably extended the work, as compared with that of 1891, to Northern and Southern California fruits.

In the following discussion of the chief points illustrated by the table, we shall use such parts of Bulletin No. 97 as answer for comparison, etc., without further reference to it.

PROPORTIONS OF PITS TO FLESH.

Prunes.—The range in the percentages of pits is from 3.7 in the Hungarian prune, No. 7, to 7.5 in the Robe de Sergent, No. 5; 5.8 per cent representing the general averages for both the French (Bulgarian, No. 39, with 9.2 per cent of pits, by reason of overripeness, is not included in the above statement). The later work, then, verifies our previous conclusion that these fruits contain about seventeen times as much flesh *as pits.*

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Plums.—In these the range in the percentages of pits, somewhat less than that for prunes, is from 3.4 per cent in Coe's Golden Drop, No. 45, to 6.1 per cent in Yellow Egg, No. 47, the average being 4.8 per cent, leaving nearly twenty times as much flesh as pits. The consumer thus finds that the plums possess a small advantage over the prunes; and the prunes on the whole, as compared with each other, show no appreciable advantage in the proportion of pits to flesh.

Apricots.—For the fully ripe and largely grown varieties from all localities the variation of pit percentages is from 5.3 (Moorpark, No. 30) to 7.1 (Royal, No. 26), a smaller difference than is found in the prunes or plums, viz., 3.8 per cent for prunes and 2.7 for plums, as against 1.8 for apricots. The average pit contents is 6.2 per cent; the flesh then is fifteen times more in amount than pits. Here again there is but a trifling advantage in choice of varieties, so far as the proportion between flesh and pit is concerned.

For equal weights of prunes and apricots (whole fresh fruit), the consumer receives nearly the same amount of flesh or available matter; but the apricots being about 2.7 times larger than the prunes, we have, on the average, 7.5 of apricots as against 20.3 of prunes per pound avoirdupois. This same difference seems to exist between the plums and prunes.

European analyses of these fruits report figures which do not differ materially from those furnished in the above table; the average pit percentages for prunes is 5.4, for apricots 5.3, the weights for whole fruits not being given in the analyses at hand.

The proportion, on the average, of shells to kernels in the pits of the prunes and apricots examined seems to be very constant and nearly the same for both fruits, or about as three to one. The kernels of all of these fruits were full and well developed; the largest pits, however, do not show, for either of these fruits, correspondingly heavy kernels.

PROPORTION OF JUICE TO FLESH.

Prunes and Plums.—The French prune on the average shows the largest proportion of free juice, 4.3 per cent more than the average for all the prunes, namely, 83 per cent, or about *four fifths* of the flesh. No. 7, Hungarian, while the largest of the prunes, has 13 per cent less juice than the average French prune, *i. e.*, 70 as against 83 per cent. The *plums*, although not as large as the Hungarian prune, are, on an average, about 5 per cent higher in juice, a figure which nearly expresses the difference between the French prunes and the plums. *Three fourths* of the flesh of the plum, as an average, is juice, thus showing the prune flesh to be one twentieth more juicy than that of the plum.

Apricots.—The proportion of juice to flesh is nearly the same for all the samples, nine tenths of the flesh being juice. No. 29, Hemskirk, with 93 per cent, being the juciest, and Blenheim, No. 15, with 85 per cent, the driest of the series. The average flesh of the apricots, from this latest showing, is more juicy than that of the prunes, in the ratio of nine to eight.

SUGAR CONTENTS OF THE JUICE, FLESH, AND FRUIT.

The work undertaken for the crops of 1891 and 1892 did not comprehend the determination of the different sugars (dextrose, levulose, cane sugar, etc.), contained in prunes and apricots; the length of time neces-

sary to complete such an investigation for each sample, required us to limit the work to the determination of the most important point—the total sugars.

Prunes and Plums.—The ripe, juicy, soft-fleshed French prunes from all localities yield the highest percentage of sugar, averaging in the juice 23.69 per cent; the hard-fleshed ripe prunes, represented by Nos. 4, 5, 37, 6, 38, 7, 8, 9, 10, and 12, yield an average of 15.24 per cent of sugar, or 6.24 per cent less than the soft-fleshed; while the average of both soft and hard-fleshed varieties is 20 per cent less than that of the French prunes.

We note, for the later crop of French prunes, a difference of five weeks between the earliest and the latest picking; No. 34 was picked on September 1st, and No. 31 on October 7th, yet these contain nearly identical amounts of sugar in the juice, 25.30 per cent, which when referred to the fresh fruit shows the *earlier* sample to stand 1 per cent lower than the later, on account of its being more juicy.

The maximum sugar percentage, 26.45, in the juice is seen in No. 32, from Newcastle, picked on September 23d; it is 1.45 per cent higher than is found in the earliest and latest French prunes. This sample and the others from the various localities gathered in the *third* and *fourth* week of September, point to that time as yielding the juiciest and sweetest fruits of their kind. No. 42, from Pomona, shows the least sugar in the juice, 17.68 per cent; this sample, after keeping three weeks at a temperature of 60° F., was still only a little shriveled and quite edible, and its juice contained 33.10 per cent sugar, or nearly double that of the original sample.

Referring again to the so-called hard-fleshed varieties, Robe de Sergent, Fellenberg, Bulgarian, etc., we note some differences in the sugar contents in favor of the later crop samples. No. 37, Robe de Sergent, shows 5.38 per cent more than No. 5; No. 38, Fellenberg, 2.5 per cent more than No. 6; No. 39, Bulgarian, nearly 13 per cent more than No. 8; a difference rather greater than we could probably expect if the samples were more nearly alike in maturity. No. 39, as above stated in its description, was far overripe. Some of these results may be explained as due to the evident difference in maturity at the time of the examination for the two crops, and, as Mr. Rock writes in the description above, to the general inferiority of the earlier crop (1891).

The *plums* among themselves show, in the juice, a narrow range in sugar, and average about 18.0 per cent of that substance—some 5.5 per cent less than the French prunes, and about 3.5 more than the hard-fleshed varieties.

Apricots.—The fruit from early localities (picked in June) and that from later points (picked in August) show a remarkably close resemblance to each other in their sugar contents—the Royal, No. 16, with its 15.06 per cent; the Peach, No. 17, with 15.72 per cent, the highest in sugar, showing but about 2 per cent more than the general average, 13.31 per cent, for the juice.

Taking the general averages of sugar in the juice of prunes and of apricots, we find that the prunes run over 6 per cent higher; for the whole fruit, somewhat 4.2 per higher. And as compared with the average French prune, the apricots show for the juice some 10 per cent less of sugar; for the whole fruit, somewhat over 7 per cent less of sugar.

When calculated on the *whole* fruit, the sugars of the apricots and

plums more nearly resemble each other in amount, the average difference being 1.79 per cent in favor of the plum. From the results at hand, it seems that the nectarine, No. 48, has in the juice nearly 4 per cent more of sugar than the apricot, following in this respect very closely the plums.

European reports of these fruits show that the *juice* of prunes, on the the average, contains 6.15 per cent sugar, and that of apricots 4.69 per cent (one case is reported of a small variety of apricots with 16.5 per cent sugar), these figures being about three times less than those herein presented for these fruits as grown in California. There seems thus to be good cause for the preference they have so quickly attained in the market.

By reference to the small table following, the relations to each other of the average *sugar* and *acid* contents of some California fruits will readily be seen. For convenience of comparison, the acid is expressed in terms of sulphuric acid (SO_3):

Percentages of Sugar and Acid.

No. Analyzed	Fruits.	Juice.		Flesh.	Whole Fruit.
		Acid, Per Cent.	Sugar, Per Cent.		
11	Apricots	.68	13.31	11.93	11.10
23	Prunes	.40	20.00	16.11	15.35
13	French prunes	.31	23.69	19.70	18.53
3	Plums	.48	17.97	13.25	12.89
2	Peaches from Shasta and Butte Counties	.24	17.00	13.40	12.50
1	Nectarines	.62	17.17	15.13	14.11
----	Grapes from various localities	.50	24.00	23.00	20.70
80	Oranges from various localities	1.28	10.68	7.12	5.40
28	Figs	.21	19.70	------	19.20

ACID IN THE JUICE.

Prunes.—The maximum, nearly 1 per cent, is at once seen in Hungarian, No. 7; the minimum, 0.23 per cent, in the Prune d'Agen, No. 1; the average, 0.40 per cent, being almost twice the minimum.

Plums.—Here again we find a very wide difference, even greater than the prunes show; the maximum being 1 per cent, the minimum 0.20 per cent, and the average 0.48 per cent.

Apricots.—While the acids differ from 0.50 per cent to 0.90 per cent, they do not show as great a diversity as the prunes in this respect, but, on an average, contain, like the nectarine, about 0.20 per cent more of acid.

In all of these fruits it appears that low acids are combined with high sugars. European analyses, which report the acid in terms of malic acid, when corrected for sulphuric acid, as in our report, give for prunes 0.51, for apricots 0.70, and for peaches 0.55 per cent, and these do not differ much, except for peaches, from the results which we give.

NUTRITIVE VALUES—NITROGEN CONTENTS.

"The flesh-forming ingredients of any article of food being of great importance as regards its proper uses (see Bulletin 93 of the department, relating to oranges and lemons), it is of especial interest to compare in

this respect the prune, plum, and apricot to other fruits, and the different varieties of prunes, plums, and apricots amongst themselves."

The *prunes* of the last crop (1892) have, in general, yielded a higher average albuminoid percentage in the flesh, for we find 0.84 as against 0.76 per cent for crop of 1891. The maximum of the series is seen in Nos. 33 and 44, French prunes, which contain, in the edible portion alone, 1.30 per cent albuminoids, or 0.36 per cent more than the maximum (0.94 per cent) of the crop of 1891. At no great distance we see placed No. 34, with 1.12 per cent of these materials; No. 5, Robe de Sergent, still shows the minimum amount, 0.52 per cent.

The French prunes and *plums* have the same quantity of albuminoids in the flesh, 1.12 per cent. In as far as these flesh-forming ingredients were determined in the hard-fleshed varieties, we do not find such differences as in the French prunes in total amounts between the two crops; Nos. 6 and 38, Fallenberg, having, respectively, 0.139 and 0.140 per cents total, and 0.117 and 0.113 per cents in the fresh flesh; Nos. 5 and 37, Robe de Sergent, yield for totals respectively 0.134 and 0.130 per cents, and for fresh flesh 0.083 and 0.113 per cents.

Among the *apricots*, the flesh shows wide differences in albuminoids, that of Central California fruits yielding the highest figures in most instances, and as compared with prune flesh, much greater variation. The maximum of 1.44 per cent albuminoids, in the flesh, is at once seen in No. 25, Royal, from Contra Costa County, and the minimum of 0.737 per cent in No. 30, Moorpark, from Fresno County, with an average of 1.00 per cent for all.

The following little table shows how the different fruits we have studied may be rated in their albuminoid contents, and distribution of the same in the several parts of the fruit, as well as how they compare with European fruits:

Average Percentages of Albuminoids.

Fruit.	Number of Analyses.	In Whole Fruit, Total.	In the Fresh Flesh, or Edible Portion.	In Fresh Pits, or Rind.
			Calculated upon Whole Fresh Fruit.	
Oranges.				
California	35	1.140	.760	.380
European (Sicilian)		1.780		
Apricots.				
California	11	1.250	1.088	.162
European		.490		
Prunes.				
California	20	1.012	.837	.175
European		.780		
Plums.				
California	3	1.130	1.000	.130
European		.400		
Apples and Pears.				
European		.375		
Figs.				
California	28	1.522	(1.522)	
European (Smyrna)		1.420		
Nectarines		.731	.625	.106

So far then, the fig rates *first* in flesh-forming ingredients, with little choice between the apricots and plums for *second;* and for *third* place, the prunes and oranges run nearly even. Apparently, the nectarine falls far short of the above fruits in these ingredients, but still ranges considerably higher than apples and pears (from European data only).

With this portion of our work we give below a summary of the food constituents of some of our dried (cured) commercial French prunes, dried apricots, grapes, and figs. The results, while inadequate as a basis for general conclusions as to the relative food values of these fruits, nevertheless indicate plainly that the nutrients, notably the sugar and crude protein (albuminoids), differ very widely; for instance, the sugar in the grape food is about 53, while that in the apricot and apple respectively is 29.5 and 32; and for the French prune 40.5 per cent, and only 5.00 less than is given for the dried fig (White Adriatic). Again, the fig with its 4.50 per cent of crude protein is 1.60 per cent richer than the grape, apricot, and the French prunes; however, these latter fruits are all nearly twice as rich in albuminoids as the apple. The maximum ash is found in the fig, and is on an average about one per cent more than that in the other fruits.

Percentage Composition of Dried Fruits.

Contents—Per Cent.	Dried Edible Portion.		Grapes (Black Malvasia "Grape Food")*	Figs (White Adriatic)	Figs (European, Smyrna)	Apples (European)
	French Prunes	Apricots				
Water	25.20	32.44	34.83	25.00	20.03	33.00
Ash	1.50	1.38	1.16	2.24	2.45	1.40
Albuminoids (crude protein)	2.80	2.90	2.94	4.50	5.70	1.70
Crude fiber			3.70			8.30
Nitrogen-free extract	29.77	32.18	2.17	10.11	13.82	21.60
Fat			.56			
Sugar	40.53	29.59	52.50	57.60	58.00	32.00
Free acid, calculated as sulphuric (SO_3)	.40	1.51	.85	.45		2.00
Tannin			1.29			
Total	100.00	100.00	100.00	100.00	100.00	100.00

*Dried and ground by R. E. Wood, Rutherford, Napa County, Cal.

Under this head, *nitrogen contents*, it is worth referring again to the large table to call attention to the distribution of the *nitrogen* in the several portions of these fruits. First, then, it is readily seen that the flesh holds 85 per cent of all the nitrogen, leaving 15 per cent of it as waste, so far as food values are concerned. Second, the proportional distribution of the nitrogen in the pits of the prunes and apricots to the *kernels* and *shells* appears to rate on the whole about the same (12 to 1), although we note great variation in this respect in both fruits.

ASH COMPOSITION AND NITROGEN CONTENTS.

Contrary to statements in our previous publications (Bulletins Nos. 88 and 93 of this department), in which, according to European data, the orange stands second (grapes being first) among fruits in the quan-

ANALYSES OF THE ASH OF PRUNES AND APRICOTS.

Number	Fruit.	Place of Production.	Percentage of Pure Ash	Composition of Pure Ash.												
				Potash	Soda	Lime	Magnesia	Peroxid of Iron	Bi. Oxid of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less excess of Oxygen due to Chlorine.	Totals
	French Prunes.															
33	Whole fruit	Yuba City, Sutter Co.	.567	66.92	.92	6.27	5.56	1.70	.36	12.91	2.54	2.67	.43	99.98	.10	99.88
	Flesh		.523	70.72	.84	5.48	5.02	1.30	.18	11.16	2.40	2.44	.46	100.00	.11	99.89
	Pits		.751	24.63	2.13	15.04	11.58	6.13	2.38	29.49	4.13	5.33	.13	99.97	.03	99.94
3	Whole fruit	San José, Santa Clara Co.	.442	65.92	3.18	3.24	6.16	.85	.31	13.19	2.37	4.56	.19	99.97	.05	99.92
	Flesh		.434	69.50	3.07	3.01	5.33	.83	.17	11.56	2.13	4.30	.20	100.10	.05	100.05
	Pits		.582	24.01	4.53	6.04	16.26	1.14	1.90	32.98	5.40	7.88	.22	100.16	.05	100.11
42	Whole fruit	Pomona, Los Angeles Co.	.450	63.67	3.20	4.48	4.70	1.89	.51	16.14	3.15	1.99	.40	100.13	.10	100.03
	Flesh		.430	67.87	2.99	3.66	4.23	1.06	.33	15.23	2.84	1.46	.37	100.04	.09	99.95
	Pits		.850	20.60	5.33	12.96	9.72	10.41	2.31	25.92	4.63	7.41	.72	100.01	.18	99.83
53	**Average (whole fruit)**		.486	63.83	2.65	4.66	5.47	2.72	.39	14.08	2.68	3.07	.34	99.99	.08	99.91
	Royal Apricots.															
16	Whole fruit	Niles, Alameda Co.	.550	54.88	10.57	3.52	3.85	1.71	.21	13.86	2.95	7.85	.60	100.00	.15	99.85
	Flesh		.542	58.59	11.20	3.24	3.31	.77	.09	11.20	2.75	8.31	.58	100.04	.14	99.90
	Pits		.681	10.95	3.45	6.75	11.58	12.39	1.65	43.76	5.38	2.58	1.65	100.14	.40	99.74
28	Whole fruit	Pomona, Los Angeles Co.	.467	63.85	9.95	2.82	3.52	1.66	.54	12.33	2.32	2.62	.30	99.91	.08	99.83
	Flesh		.459	67.00	10.23	2.65	2.89	.97	.39	10.88	2.35	2.27	.28	100.11	.07	100.04
	Pits		.592	23.09	6.45	6.58	11.22	10.06	2.20	30.96	1.84	7.09	.51	100.00	.12	99.88
54	**Average (whole fruit)**		.508	59.36	10.26	3.17	3.68	1.68	.37	13.09	2.63	5.23	.45	99.92	.11	99.81

tity of mineral matter withdrawn from the soil, we find that, weight for weight, the fig has *second* place, the orange *third*, and the prune, apricot, and plum *fourth* place; thus more than ever bringing before us the fact that we cannot safely use European results as a basis of comparison for our fruits.

Using as a basis the preceding table of this publication, those given in Bulletins Nos. 93 and 97, and the work upon our figs, we have prepared the following tabular view of the amounts, in pounds, of vital soil ingredients extracted by the different fruit crops (poor fruit alone) that are withdrawn from the soil by different crops.

Soil Ingredients Extracted from the Soil by Different Fruit Crops.

Fruits.	Total Ash. Pounds.	Potash. Pounds.	Phos. Acid. Pounds.	Nitrogen. Pounds.
Grapes.				
European—				
In each 1,000 pounds	8.80	5.00	1.52	1.70
Apricots.				
European—				
In each 1,000 pounds	4.90	----	----	.86
Crop of 30,000 pounds	147.00	----	----	25.80
California—				
In each 1,000 pounds	4.91	2.90	.64	1.94
Crop of 30,000 pounds	147.30	87.00	19.20	59.20
Prunes.				
European—				
In each 1,000 pounds	6.30	3.73	.95	1.22
Crop of 30,000 pounds	189.00	111.90	28.53	36.60
California—				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
Plums.				
In each 1,000 pounds (California)	5.35	----	----	1.81
Oranges.				
European—				
In each 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60
Figs.				
European—				
In each 1,000 pounds	8.00	2.27	.10	2.27
Crop of 15,000 pounds	120.00	34.05	1.50	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70

California *prunes* thus appear to draw much less upon the mineral ingredients which have to be replaced by fertilization than the European; the latter, however, draw much more lightly than the former upon nitrogen. *Apricots*, both of California and European growth, stand about equal as to total mineral ingredients withdrawn; of nitrogen, the California fruit draws twice as much, showing the only very material difference in the relative proportions of the vital soil ingredients among themselves as far as these two fruits are concerned.

Potash.—In the ashes of prunes and apricots and in the orange, potash is seen to be the leading ingredient; comprising in the prunes and apricots fully three fifths of the whole ash, and in the orange at least one half. In its distribution as between pits and flesh, the greatest difference is shown in the European prune; for apricots we have no

foreign data. Although potash constitutes so large a portion of the ash of these fruits, its replenishment to the soil will be delayed long beyond the addition of other fertilizing ingredients; most California soils are naturally so well stocked with available potash that the current demand will be adequately supplied for many years.

Phosphoric Acid seems not to be so heavily drawn upon by California fruits as by European. Its distribution between pits and flesh, also, is not quite so variable as that of potash. Since our soils usually contain a limited supply of phosphoric acid, the prune and apricot as well as the orange orchards will require *phosphates* first when fertilizers are used.

Nitrogen.—Among our pitted fruits the apricot leads in its demand upon the soil for this substance, plums being quite the average of the apricots and prunes, and resemble very much the orange in this respect. Thus we find, for the southern localities especially, the same necessity of an early replacement of nitrogen in pitted fruit as for orange orchards; and partly for the same reason, viz., that California soils are usually not rich in their natural supply of this substance.

Of the other ash ingredients, it will be seen that *lime* is quite constant, although much less in amount (for prunes) than European standards show. Especially is this difference seen in the comparison of the ash analyses of the flesh and pits. In the orange ash the lime content far exceeds that of either the prune or apricot; accordingly, as our soils generally contain plenty of lime, even for oranges, we would rarely expect to fertilize with a view to its replacement. *Soda* is seen to be much higher here than in European analyses of the ash of the prune; this is probably explained by the fact that California soils, like those of other arid regions, contain much more soda than the European.

ADDITIONAL PROXIMATE ANALYSES OF PRUNES AND APRICOTS (CROP OF 1893); SAMPLES SENT BY GROWERS FOR ANALYSIS.

The work here reported was performed at the request of the growers of the several fruits, and was done after the preparation of the above paper.

No. 60. *Dried French Prune*, from Wrights Station, Santa Clara County; grown by W. H. Aiken, and received January 16, 1894. A fair sample of dried French prunes, of average size and sweetness.

No. 56. *Petite d'Agen*, from Arroyo Grande, San Luis Obispo County; grown by King Bros. The sample arrived here September 16, 1894. It was rather irregular in shape—flat on one side and bellied or rounded on the other, but of good size, and with a light purplish-brown skin. Flesh was rather dry and only fairly sweet for the variety.

No. 57. *Phillia d'Agen*, from Arroyo Grande, San Luis Obispo County; grown by King Bros., and received September 16, 1893. A nearly round-shaped fruit, with purplish-brown colored skin. It is a clingstone, with golden yellow and juicy flesh.

No. 59. *French Prune*, from Manton, Tehama County; grown by Woodward Bros. An average fruit of this variety, and was received October 3, 1893.

No. 58. *Pacific Prune*, from Mount Tabor, Oregon; grown by T. V. Sluman, and received September 26, 1894. This fruit is quite as large

as an Hungarian prune, but much more nearly round in shape; the color, too, is even darker purple than that of the French prune, and the skin is marked with spots. The flesh is juicy and golden yellow in color.

No. 55. *Prune*, from Arroyo Grande, San Luis Obispo County. The variety is unknown; it was grown by King Bros., and received for examination September 4, 1893. Form oval, symmetrical; color dark purple, but cloudy; flesh greenish-yellow, and rather dry; pit free, oval, rather thin and smooth. This fruit, while nearly as large as a French prune, still has a much larger pit, and cannot compare with it in sweetness and flavor.

No. 54. *Hemskirk Apricot*, from Bakersfield, Kern County, grown by James M. Hunter, and received July 14, 1894, in good condition, and fully ripe.

The following table gives the results of the analysis of the fruits described above:

PROXIMATE ANALYSES OF PRUNES AND APRICOTS—CROP OF 1893.

Number	Variety.	Place of Production.	Name of Grower.	Date of Receipt and Analysis.	Average Weight, in Grams*.	Number per Pound	Flesh, Per Cent.	Pits, Per Cent.	Flesh.		Juice.		Sugar.	
									Juice (pressed), Per Cent	Pulp (pressed), Per Cent	Total Sugar by Copper (inversion), Per Cent.	Acid, in terms of Sulphuric (SO_3), Per Cent	In Fresh Flesh, Per Cent.	In Fresh Fruit, Per Cent.
	Prunes.													
60	French Prunes—Dried	Wrights Station, Santa Clara Co.	W. H. Aiken	Jan. 15, '94	10.0	45.0	88.0	12.0	.....	.....	.....	.....	†55.00	†48.40
56	Petit d'Agen	Arroyo Grande	King Bros.	Sept. 16, '93	24.5	18.0	94.9	5.1	71.7	28.3	17.50	.....	12.80	12.16
57	Phillia d'Agen	Arroyo Grande	King Bros.	Sept. 16, '93	25.5	17.8	95.1	4.9	75.3	24.7	17.20	.....	12.90	12.30
59	French Prunes	Manton	Woodward Bros.	Sept. 25, '93	26.7	16.0	93.2	6.8	80.0	20.0	19.00	.54	15.20	13.95
58	Pacific Prune	Mt. Tabor, Oregon	T. V. Sluman	Sept. 26, '93	69.0	6.5	97.1	2.9	85.0	15.0	11.03	.47	9.50	8.60
55	Unnamed Prune	Arroyo Grande	King Bros.	Sept. 4, '93	21.0	21.5	92.4	7.6	78.3	21.6	7.50	.....	6.50	6.00
	Apricots.													
54	Hemskirk	Bakersfield	J. M. Hunter	July 14, '93	66.0	6.8	93.7	6.3	83.0	17.0	10.50	.50	9.87	9.29

*30 grams are equivalent to 1 ounce. † These results are of course upon dried flesh and fruit.

To save too much cross-reference to figures given in table on p. 260 of this report, and those for the fruits lately examined, we prefer to explain a few of the points relating to both sets of figures.

The analysis of the dried French prune, No. 60, yields average results for this variety, in weight, pit, flesh, and sugar percentages. The Petit d'Agen and Phillia d'Agen, Nos. 56 and 57, respectively, while average-sized, are not as sweet, *i. e.*, do not contain within 3 per cent as much sugar in the fruit as the average French prune. The prune from Manton, No. 59, is only 1.30 per cent below the average in sugar (whole fruit). The unnamed variety, No. 55, from Arroyo Grande, falls very much below the French prune in sugar in the fruit—nearly 10 per cent—and so cannot be classed with that variety, although its appearance is somewhat favorable for that. The Pacific prune, No. 58, from Mount Tabor, Oregon, an extensively advertised fruit, is smaller than the Hungarian prune from San José, No. 7, possesses a somewhat smaller pit—0.7 per cent less—is more juicy, and contains about 2 per cent less sugar.

The Hemskirk apricot, No. 54, from Bakersfield, stands quite the average, in all respects, when compared with the other southern-grown apricots; the apricots grown in Central California appear to be somewhat sweeter, viz.: 11.50 per cent, as against 9.70 per cent sugar for the southern fruit.

GENERAL SUMMARY OF RESULTS.

PERCENTAGES OF FLESH AND JUICE IN THE WHOLE FRESH FRUIT AND OF THE NUTRIENTS, WATER, ETC., CONTAINED IN THE FRESH EDIBLE PORTION OF SOME CALIFORNIA FRUITS.

From the foregoing tables of fruit analyses and the records, we have attempted to indicate in the following tabular summary the amount and the composition of the *edible portion* of the different fruits examined at this Station throughout the last three or four seasons. Some of the ingredients (*fat*, *crude fiber*, and some of the *carbohydrates*) have been left undetermined, for the simple reason that other parts of the work have been more important and took up the greater portion of our time. Because of this, we will not at present try to furnish any figures for the potential energy of these foods.

AMOUNT AND COMPOSITION OF THE EDIBLE PORTION OF SOME CALIFORNIA FRUITS.

Fruits.	Number of Analyses.	In Whole Fruit.		Edible Portion.				
		Flesh, Per Cent.	Juice, Pressed, Per Cent.	Water, Per Cent.	Nutrients.			
					Protein (N. x 6.25), Per Cent.	Fat, Fiber, and Carbohydrates less Sugar, Per Cent	Sugar, Per Cent.	Mineral Matters (Pure Ash), Per Cent.
Oranges	13	73.0	52.00	88.30	.760	*3.840	7.10	-------
Lemons†	22	71.0	45.50	-------	-------	-------	1.63	-------
French Prunes	10	94.2	74.20	75.15	.944	3.641	19.70	.565
All Prunes	20	94.2	74.20	80.20	.848	2.368	16.11	.474
Plums	3	95.2	71.00	78.40	.996	6.833	13.25	.524
Apricots	11	93.9	84.50	85.07	1.042	1.477	11.93	.477
Nectarines	1	93.4	85.00	82.90	.625	.855	15.13	.490
Figs	28	100.0	77.65	79.11	1.522	3.261	15.53	.577
Grapes	3	100.0	79.00	80.12	1.256	1.624	16.50	.500

*Contains the ash.
†The whole fruit yields: Water, 85.04 per cent; organic matter, 14.42 per cent; ash, 0.535 per cent. (Nitrogen on whole fruit, 0.152 per cent, corresponds to 0.95 per cent protein.)

The edible portion of the pitted fruits named above rates at nearly 94 per cent of the whole fruit, leaving the citrus fruits with about 72 per cent flesh—some 20 per cent behind in this respect. For this part of our study we can consider the fig and grape as standing first, it being ordinarily nearly all edible, or that it does not contain waste material. When the water percentages are examined it appears that the French prunes have the least water-content, 75.2 per cent; nearest to this the plums stand, with 78.4, and the figs next, with 79.10 per cent; oranges (and doubtless lemons), with 88 per cent of water, again rating poor in comparison with the pitted fruits.

Coming now to the *nutrients* as given above (protein, or flesh-forming substances; sugar, the chief carbohydrate in these fruits; and the mineral matters or pure ash), we find interesting facts, some of which have been alluded to in previous papers relating to fruits. The fig has *first* place among the fruits examined here in regard to its content of protein matters, *one half* as much again as either the apricot, plum, or prune, and *twice* as much as the orange, lemon, or nectarine; however, the grape follows the fig rather closely. The range in average protein materials is from 0.63 per cent in the nectarine to 1.522 per cent in the fig; individual samples of figs show in some cases very much higher percentages—2.587 being the highest yet returned.

Sugar, the principal carbohydrate, varies from 19.70 per cent in the flesh of the French prune to as low as 1.65 per cent in the lemon; the orange having 7.1 per cent, the apricot about 12.0 per cent; figs, nectarines, and all prunes and grapes, upwards of 15.0 per cent of sugar.

The amount of ash, or mineral matters, shows no sensible variation from one half of one per cent in all the fruits so far studied.

ASH, AND ITS PERCENTAGE COMPOSITION IN CALIFORNIA FRUITS.

In the different fruit bulletins (Nos. 93, 97, 101, 102) and reports we have put forth the analyses of the ash of our fruits and used the figures mainly to give the amount of mineral matters withdrawn from the soil, and to show how much of the vital soil-ingredients must be added to the soil to replace them.

Collected in the following summary will be seen the averages of the amount and composition of ash in the fresh fruit of the grapes, oranges, lemons, prunes, apricots, and figs that we have had time to study.

The fig therefore contains, according to this showing, the highest amount of ash; in the three samples completely analyzed, 0.612 per cent, and for twenty-eight samples an average of 0.577 per cent. The orange shows the least amount of ash, 0.432 per cent, and the grapes, lemons, prunes, and apricots all stand so nearly at 0.500 per cent of ash that the differences are not worth noting.

Percentages of Potash.—This substance (potash), as is well known, predominates in the ash of fruits, making up from one half to nearly two thirds the whole; exceeding in the *prune* ash that of the other fruits. By the above showing it contains 63.83 per cent, or over 4.5 per cent more than the next highest in potash—the apricot ash, with 59.36 per cent. The fig ash, with 55.83 per cent, stands next, then the grape ash, with 50.95 per cent, and lastly orange and lemon ashes, with upwards of 48.0 per cent of potash.

Percentages of Soda.—This ingredient, while unimportant, shows rather greater variation, even for same fruits. In the above summary it runs from 1.76 per cent in ash of lemons to 10.26 per cent in apricot ash; grape ash being next to the highest, with 6.32 per cent soda.

Percentages of Lime.—This valuable substance shows much greater differences than either the potash or the soda; for the *lemon* ash, with 29.87 per cent of lime, contains nearly *ten* times more than the apricot ash, with 3.17 per cent of lime; the ashes of prunes and grapes have only somewhat over 4 per cent of lime. Next to the lemon comes the orange ash, with 22.70 per cent of lime—over twice as much as the fig ash contains.

Percentages of Phosphoric Acid.—This highly important portion of the ash of fruits is quite constant in the majority of the ashes; lemon ash containing the least amount, 11.09 per cent; orange and fig ashes, over 12.0 per cent.; apricot ash, 13.0 per cent, and prune ash, 14.0 per cent. Grape ash leads in phosphoric acid, averaging over one fifth of the whole ash, or 21.24 per cent.

Percentages of Magnesia, Peroxid of Iron, Oxid of Manganese, Sulphuric Acid, Silica, and Chlorine.—Like the soda, these ingredients are rated as unimportant and show but few *wide* differences. The *peroxid of iron* in the lemon ash, 0.43 per cent, is from one sixth to one half that in some of the other ashes. *Silica* ranges from 0.65 per cent in the citrus fruit ashes to as much as 5.20 per cent in the ashes of apricots and grapes. *Chlorine* in the prune ash is but 0.34 per cent; that in the fig ash is over six times as much, or 2.05 per cent.

AMOUNT AND COMPOSITION OF THE ASH OF SOME CALIFORNIA FRUITS.

Whole Fruit.	Number of Analyses	Percentage of Pure Ash	Composition of the Pure Ash.												
			Potash	Soda	Lime	Magnesia	Peroxid of Iron	Br. Oxid of Manganese	Phosphoric Acid	Sulphuric Acid	Silica	Chlorine	Total	Less Excess of Oxygen, due to Chlorine	Total
Grapes*	5	.500	50.95	6.32	4.96	3.04	2.73	.36	21.24	4.28	5.31	1.54	100.73	.33	100.40
Oranges	9	.432	48.94	2.50	22.71	5.34	.97	.37	12.37	5.25	.65	.92	100.02	.20	99.82
Lemons	2	.526	48.26	1.76	29.87	4.40	.43	.28	11.09	2.84	.66	.39	99.98	.09	99.89
Prunes, French	3	.486	63.83	2.65	4.66	5.47	2.72	.39	14.08	2.68	3.07	.34	99.99	.08	99.91
Apricots, Royal	2	.508	59.36	10.26	3.17	3.68	1.68	.37	13.09	2.63	5.23	.45	99.92	.11	99.81
Figs	3	.612	55.83	2.38	10.90	5.63	2.19	.21	12.42	3.95	4.33	2.05	99.89	.44	99.45

*Analyzed by F. T. Bioletti, of this Station staff.

ANALYSES OF BANANAS AND BANANA SOILS FROM THE SANDWICH ISLANDS.

By Geo. E. Colby.

This investigation was made for Mr. A. J. Campbell, of Honolulu, H. I., during the vacation of 1886, and is reported now, by his permission, in view of the interest attaching to this culture in California, both from the standpoint of the cultivator and the fertilizer manufacturer. Then, too, the report by Mr. Campbell upon fertilizer experiments recommended by Professor Hilgard and based upon the analyses of the soils and the ash of the leaves and fruit of the banana, is of interest.

Under the date of April 11, 1886, Mr. Campbell wrote to Professor Hilgard: "I take the liberty of sending you two samples of soils and their corresponding subsoils. My desire is to find out the fertilizer these soils require, in a general way, and what specially for a banana crop, which seems to be very exhaustive to the soil. The samples represent the two varieties of soil at and in the vicinity of my banana plantation, and were prepared as described in one of your University bulletins (No. 26). No. 1 was taken to a depth of 13 inches and the subsoil an additional 13 inches. No. 2 was taken to a depth of 12 inches and the subsoil an additional 13 inches. These samples come from a very dry district, where irrigation is necessary and the irrigating waters contain silicates of sodium and potassium. No. 2 seems to be a heavy adobe soil. Both crack when dry. No. 1 becomes very soft after rains, while No. 2 gets very sticky. No. 2 is a red, clayey-looking soil, which gives good crops of almost anything. The lighter-colored, No. 1, does not seem so fertile."

The soils were sampled and analyzed in accordance with the methods usually pursued in the Station laboratory, with the following results:

ANALYSES OF SOILS AND SUBSOILS FROM THE BANANA PLANTATION OF A. J. CAMPBELL, HONOLULU, H. I.

	No. 1, Dark-Colored.		No. 2, Chocolate-Colored.	
	Soil. Depth, 0—13″.	Subsoil. Depth, 13″—26″.	Soil. Depth, 0—12″.	Subsoil. Depth, 12″—25″.
Coarse materials>0.5mm.	None	None	None	None.
Fine earth	All	All	All	All.
Analysis of Fine Earth.				
Insoluble matter	13.050	12.956	15.913	13.905
Soluble silica	26.755 } 39.805	25.129 } 38.085	23.072 } 38.985	26.027 } 39.932
Potash (K_2O)	.243	.221	.222	.400
Soda (Na_2O)	.123	.154	.062	.108
Lime (CaO)	.221	.187	.442	.241
Magnesia (MgO)	.517	.432	.685	.641
Br. ox. of manganese (Mn_3O_4)	.189	.126	.637	.680
Peroxid of iron (Fe_2O_3)	21.170	22.244	17.525	20.153
Alumina (Al_2O_3)	24.149	25.246	26.835	26.061
Phosphoric acid (P_2O_5)	.121	.205	.197	.129
Sulphuric acid (SO_3)	.005	.005	.004	.005
Carbonic acid (CO_2)	----------	----------	----------	----------
Water and organic matter	13.722	13.416	14.362	12.061
Total	100.265	100.321	99.956	100.411
Humus	1.097	----------	1.455	----------
Humus ash	.714	----------	1.226	----------
Containing phosphoric acid	.047	----------	.085	----------
Humus-nitrogen in 100 humus	6.580	----------	6.200	----------
Humus-nitrogen in 100 fine earth	.072	----------	.090	----------
Hygroscopic moisture absorbed at 13°C.	13.700	14.400	12.200	13.05

The above soil analyses are thus discussed by Professor Hilgard: "Contrary to my expectations the two do not differ widely, and are evidently of similar origin. It is curious that the darker colored soil, No. 1, actually contains less humus than No. 2, the red one, owing doubtless to the different condition of the humus. Of this substance, however, there is in both an adequate supply. As regards the other ingredients, potash is in quite small supply, when taken in connection with the supply of lime. The whole analysis indicates that these two substances should be supplied to the soil. Phosphoric acid is not only in adequate total supply, but so large a proportion of it is in an available state that the use of phosphate fertilizers is not at present indicated and would probably not pay for some time to come."

ANALYSES OF LEAVES AND FRUIT OF THE BANANA.

For the analysis of the leaves, the wrapping of a bunch of fruit sent by Mr. Campbell was used. The dried leaves were calculated to fresh ones from the result of a drying experiment with the leaves taken from a hot-house plant.

The *sand* held by the leaves mechanically was removed from the ash by treating the *insoluble residue* with carbonate of soda solution. For

the analysis of the fruit a fresh sample of Sandwich Island banana was bought in the San Francisco market, as soon as possible after the arrival of the steamer.

The tables below show: (1) The *proximate analysis* of the *fruit* (results are given upon dried and fresh substance); (2) The analysis of the *ash* of the *fruit*, comprising the percentage composition with the same referred to *fresh* and *dried* fruit; (3) The proximate analysis of the *leaves* of the banana with figures arranged so as to give the returns upon the substance *dried at 100°* C., *air-dried*, and *fresh*, and in addition the parts, in pounds, these figures hold when calculated upon the weight (9.3 pounds) of fresh leaves used as wrapping for one bunch of bananas.

1. PROXIMATE ANALYSES OF THE FRUIT OF THE BANANA, FRESH SAMPLE PROCURED IN THE SAN FRANCISCO MARKET.

	Dried at 100° C.	Fresh.
Water	.....	82.060
Carbohydrates, etc.	90.624	16.256
Albuminoids (crude protein)*	3.369	.606
Ash	6.007	1.078
Totals	100.000	100.000

*Determined by the soda-lime method.

2. ANALYSIS OF THE ASH OF THE FRUIT.

	Percentage Composition of the Ash.	Composition of the Ash. Referred to	
		Fruit Dried at 100° C.	Fresh Fruit.
Silica (SiO_2)	5.512	.332	.0595
Potash (K_2O)	63.066	3.788	.6800
Soda (Na_2O)	2.348	.141	.0250
Lime (CaO)	.860	.052	.0093
Magnesia (MgO)	2.940	.177	.0317
Br. ox. of Manganese (Mn_3O_4)	.115	.007	.0010
Peroxid of iron (Fe_2O_3)	.229	.014	.0034
Alumina (Al_2O_3)			
Phosphoric acid (P_2O_5)	1.620	.098	.0175
Sulphuric acid (SO_3)	2.329	.139	.0250
Chlorine (Cl)	26.930	1.618	.2905
Totals	105.949	6.366	1.1429
Less oxygen corresponding to chlorine	6.087	.365	.0656
	99.862	6.001	1.0773

3. PROXIMATE ANALYSES OF THE LEAVES OF THE BANANA FROM THE PLANTATION OF A. J. CAMPBELL, HONOLULU, H. I.

	Leaves of the Banana.			
	Dried at 100° C.	Air-dried.	Fresh.	†Weight in lbs. of Ingredients of the Leaves.
Water	.....	11.443	83.953	7.842
Organic matter (not nitrogenous)	79.31	70.235	12.723	1.189
Albuminoids (crude protein)*	9.25	8.180	1.490	.139
Ash	11.44	10.142	1.834	.171
Total	100.00	100.000	100.000	9.341

*Determined by the soda-lime method.
†Calculated upon the weight (9.34 lbs.) of fresh leaves used to wrap one bunch of bananas.

4. ANALYSIS OF THE ASH OF THE LEAVES OF THE BANANA.

	Percentage Composition of the Ash.	Composition of the Ash referred to Leaves.		Parts of a Pound of Ingredients of Ash, calculated on 9.341 lbs.
		Dried at 100° C.	Air-dried.	Fresh.	
Silica (SiO_2)	23.900	2.734	2.418	.438	.0409
Potash (K_2O)	27.552	3.151	2.852	.505	.0472
Soda (Na_2O)	.304	.035	.031	.006	.0005
Lime (CaO)	17.882	2.046	1.809	.328	.0306
Magnesia (MgO)	8.146	.932	.824	.149	.0139
Br.ox.of Manganese(Mn_3O_4)	.573	.066	.058	.011	.0010
Peroxid of iron (Fe_2O_3)	3.177	.363	.321	.058	.0054
Alumina (Al_2O_3)					
Phosphoric acid (P_2O_5)	.638	.073	.065	.012	.0011
Sulphuric acid (SO_3)	3.413	.391	.345	.063	.0058
Chlorine (Cl)	18.550	2.122	1.877	.340	.0318
Total	104.135	11.913	10.600	1.910	.1782
Less oxygen corresponding to chlorine	4.180	.478	.423	.077	.0072
	99.955	11.435	10.177	1.833	.1710

Of these results Professor Hilgard says: "The analysis of the leaf ash shows that potash, lime, and chlorine are the ingredients chiefly drawn upon by the leaves, but the total amount of these contained in the wrapping of a bunch is only 0.17 of a pound, and the potash so withdrawn only amounts to half a tenth (0.05) of a pound per bunch.

"The ash of the fruit itself is very much less than that of the leaves, but it contains much more of the important elements; 63 per cent of it is potash, which, with chlorine, forms the predominant ingredient—potassic chlorid. Assuming the average weight of a bunch of bananas to be 80 pounds, each bunch carries with it 0.86 of a pound of ash, of which 0.55 is potassic chlorid or commercial muriate. Taking 500 as the average number of bunches of fruit per acre (planting 9 by 9 feet), there will be extracted 275 pounds of potash by each crop, or, with the leaf wrappers, nearly 300. This draft upon the relatively small potash supply in the soil is, in all probability, the chief cause of the falling-off *of the prod*uction. But there is another point: While the fruit is not

very rich in albuminoids, the leaves contain nearly as much as average meadow hay. The wrappings of each bunch of bananas carry away, say, 0.15 of a pound of the same, each bunch of bananas about 0.25 of a pound, or over two fifths of a pound for each bunch packed. This is quite a heavy draft per acre; when it is multiplied by the number of bunches, it is over ten times as much as for a wheat crop, for example. Evidently, some nitrogenous fertilizer should be supplied.

"*Conclusions.*—The fertilizers indicated by the analyses of the soils as well as by that of the fruit and leaves are potash salts, or *kainite* on the one hand, and Chili saltpeter on the other. Kainite would best be imported direct from Germany, the other from Chili or from this market. As to the quantity to be used per acre, the soil in its present condition, according to the analyses, will supply one half of the potash required by the crop. The deficiency, the other half, must be furnished by fertilizers in order to obtain a maximum (full) crop. A preliminary experiment with a smaller proportion should be tried. For example, a mixture of 500 pounds of *muriate* and 200 pounds of tankage, dried blood, or some other nitrogenous fertilizer, might be tried per acre, with lime in the shape of coral sand from the beach, or such other matter as may be convenient or cheap. Above all, whatever offal may be available, including stable manure, should be returned to the soil. The chlorine needed will also be supplied by the fertilizers recommended above, but as an additional experiment a dressing of salt may be applied."

The report from Mr. Campbell upon his experiments with fertilizers for bananas reads: "Potash I consider the proper fertilizer for bananas, although the results obtained on soil No. 1 (dark-colored) were not as good as those obtained on No. 2 (chocolate-colored), upon which I have fair, in fact, good success." There is nothing in the report to the effect that any lime or nitrogenous fertilizer was used in the experiments.

OLIVES AND OLIVE OILS.

By Arthur P. Hayne.

DESCRIPTIONS OF OLIVE VARIETIES.

In presenting descriptions of olive varieties, we do not mean to claim that they are complete or perfect; there are none other more complete in existence, so far as known. What has been written on the subject is, for the most part, scattered through many works in foreign languages, and is not available, least of all to the olive-growers of California. Constant requests for information reaching the College of Agriculture seem to render it expedient to publish what is at hand, with the intention to correct hereafter any errors, and to enlarge the work as fast as we may be able to obtain definite information.

In making this compilation we have taken all available data from French, Spanish, and Italian works, together with personal observations in Europe and California, giving all that was deemed reliable.

The University has some fifty-five varieties growing (though not all bearing) at the five culture stations connected with the College of Agriculture. Besides these we have been able to avail ourselves of the public-

spirited aid of various olive growers, who have sent us samples of olives for experiment and analysis. It is to be hoped that all those who grow olives (especially new varieties) in new regions will send samples to the Agricultural Experiment Station at Berkeley, so that the work of investigation may be carried on along the lines already laid down.

The following brief description of olive varieties, oil mills, etc., must then be taken as answers to questions that come to us daily, not as an attempt at a complete or original work on olives.

The analyses of foreign olives in the following descriptions were made in France by Professor Bouffard, of the Montpellier School; those from California by George E. Colby in the Viticultural Laboratory of the University Experiment Station.

LUCQUES.

SYNONYMS: *Olive de Lucques, Lucquoise, Oliverolle, Oderante; Olea minor, lucensis, fructu oblongo, incurvo, odorato* (Tournefort); *Olea europæa ceratocarpa* (Clemente).

This variety is frequently confounded with the Picholine, with which it presents certain analogies of form. There is no good reason, however, for confusing the two.

TREE of medium vigor and development; semi-erect grower; *trunk* cylindrical; the *bark* detaches in long strips so readily that the trunk is sometimes denuded of its covering; main branches semi-erect or horizontal; general appearance is always that of a vase; *suckers* not numerous; *branches* vigorous, long, straight, erect, or horizontal, with abundant young growth growing at right angles, drooping when young, and of a clear gray color; *wood* in the form of a hexagon, especially at the extremities of the young growth; *eyes* prominent.

LEAF medium long and narrow (mean length, 6 to 9 centimeters; width, $\frac{3}{4}$ to 1 centimeter.) Superior surface clear green, slightly red. Inferior surface with slight dirty white deposit. *Nerves* not well defined, even on the superior surface. *Petiole* long, thin, and bent over. The leaf has its edges folded over, and is not equally divided by the main nerve. It is not heavily clothed with leaves.

FRUIT frequently single, the greater part distributed at the base of the branches of a year's growth. *Peduncle* long, thin, inserted in a very slight depression in the fruit. *Stigma* persistent in a well-defined umbilicus.

FRUIT medium large (mean length, $2\frac{1}{2}$ to 3 centimeters; thickness, $1\frac{1}{4}$ to $1\frac{1}{2}$ centimeters), crescent-shaped, the surface opposite the curvature almost rectilinear. The form is very characteristic. In *color* it passes from a clear green to a shiny blue-black with very little bloom. *Skin* thin, and *pulp* abundant; *pit* medium large, the same form as the fruit; maturity early.

Analysis of the Lucques.

	France.	California.
Number of olives in 100 grams		
Percentage of pit in whole fruit	20.00	30.00
Percentage of flesh in whole fruit	80.00	70.00
Percentage of oil in fresh flesh	21.55	18.70

From this comparison it would seem as though the Lucques did not prosper in California as well as in France. However, the samples of Lucques analyzed at the University were so shriveled that it is not a fair test. Making due allowance for loss, we are safe in supposing that there is but little real difference.

This variety is not widely known, except in localities where the chief industry is that of pickling the olive. Some claim that it is of Italian origin, but it is well known in Spain, where it does very well, having the same general characters as the Lucques elsewhere. It is a variety of medium vigor and longevity.

Though it resists well the cold, it requires hot summers to mature well. It is found in all sorts of localities, but would seem to do best on hillsides where the soil is deep. On dry, shallow soils it is a failure. On the French market the olives command a higher price for pickles than any other variety.

Tablada says of it: "It needs vigorous and repeated pruning to yield annual crops."

In California there seem to be several plantations of varieties wrongly named Lucques. We call special attention to the description above.

NEVADILLO BLANCO, OR MOIRAL.

SYNONYMS: *Olivo Doncel Zorzaleña, Moradillo* (Tablada). *Moiral, Mourau, Mouraou, Moure, Mouraude, Mourescale* (Herault). *Mouraoudo* (Aude). *Olea europea argentata. Moureau, Mourelt, La More* (Gard). *Mouretto* (Aix-en-Provence). (?) *Ribière*, (?) *Ribiè*, (?) *Roubèiro* (Provence).

TREE vigorous, large, spreading grower; *bark*, gray; *suckers* ordinarily numerous; *foliage* when young very vigorous, inserted at an acute angle; *color*, at first dirty greenish-gray on the two-year-old wood; *wood* cylindrical, quadrangular only at the extremities of the young branches; *eyes* medium prominent.

LEAF medium long and wide (mean length, 6 to 7½ centimeters; width, 1¼ to 1⅜ centimeters). Superior surface shiny, deep green; inferior surface with thick deposit. Principal nerve well marked on both faces. The leaves are very plentiful, forming a thick covering to the tree.

FRUIT regularly distributed along the entire length of the branches, most frequently single, sometimes in pairs; *peduncle* short; *pedicel* long, inserted in a well-marked depression in the berry; *stigma* not apparent in well-marked umbilicus. An olive of under the medium size or small. In California it seems to be well adapted to its soils, etc., and is larger than in Europe (mean length in Europe, 1½ to 1⅝ centimeters; width, 1¼ to 1⅛ centimeters). Form almost perfectly regular, with the exception that it is slightly obtuse at the two extremities. *Pit* large, of the same shape as the berry, with a groove the entire length of the pit. The olive is of a shiny, deep black color, with very little bloom. *Skin* thick; *pulp* abundant, of a wine-red color.

The Nevadillo Blanco came to California from Spain; probably there are importations from other countries also. From the descriptions we have of it, we are led to suppose that it is more vigorous and productive in California than in Europe. But it is the first to suffer from frost. The analyses made at the University point it out as one of the best adapted varieties of the State. Here it is a remarkably regular bearer. Professors Viala and Degrully, of the Montpellier School, say of it: "It is one of the most esteemed varieties of the Languedoc, formerly exten-

sively cultivated; its chief fault being that its early maturity necessitated a separate harvest. As this variety is an exceptionally regular bearer, it is to be recommended for large plantations where its early maturity would not cause any difficulty."

Analyses of Nevadillo Blanco.

	France.	California.	Spain.
Number of olives in 100 grams	78	36	20
Percentage of pit in whole fruit	23.50	20.55	----------
Percentage of flesh in fresh fruit	76.50	79.45	----------
Percentage of oil in flesh	13.78	24.83	----------

From this comparison we see that the Nevadillo is a far more valuable variety in California than in France, as the figures are the averages from nine samples of Nevadillo Blanco grown in almost as many parts of the State. There is still a doubt if the Moiral of France is the Nevadillo Blanco of California. The resemblance is very striking, and one of the names of the Moiral in France is the Nevadillo Blanco. The *difference in size and richness in oil is not enough to lead us to suppose that the two varieties are not identical.* The difference in soil, climate, and care are alone able to account for this discrepancy in analyses. We have in California the same variety varying 20 per cent in oil contents; so we must not be too hasty in doubting the identity on account of a difference of 10 per cent in richness.

According to Tablada, the Nevadillo Blanco of Spain is the Moiral of France; but it is a native of Spain, and would seem to thrive there better than in France. It certainly does remarkably well in California in a great variety of soils and locations. While it is an excellent oil olive, it is not so well adapted for pickles as some others on account of its size, being smaller than the average Mission, which may be taken as a fair standard of comparison, being so well known in this State.

ATRORUBENS.

SYNONYMS: *Saillern, Saillerne, Sagerne* (at Nimes), *Olea minor, Rotunda, Rubro-Nigrians* (Tourneford).

This is a Southern French variety, known almost everywhere to-day as *Saillern*; but as it seems to be well known in California under the name of *Atrorubens*, it has been deemed wise to adopt this one of its synonyms in order to avoid unnecessary confusion.

TREE very vigorous, medium-sized or large; spreading grower; *trunk* very thick, enlarged at the base; *bark* peels off in fine longitudinal strips of a blackish color; *suckers* very numerous. (This variety is said to sucker more than any other); *foliage* tolerably vigorous, not generally very thick, and makes a large shoulder where it branches out; *color* dirty yellow; *eyes* prominent.

LEAF regular, short, relatively wide (mean length, 6 to 7 centimeters; mean width, 1¼ to 1½ centimeters). Superior surface shiny, clear green; inferior surface with abundant dirty white deposit; *nerves* well marked on the superior surface; *petiole* thick, short, twisted so as to cause all the leaves to be on the same side of the twig. The leaf is almost flat. *Very* few leaves in the interior of the tree.

FRUIT mostly single, sometimes in clusters of two on two-year-old wood; *peduncle* long, fruit drooping; *stigma* persistent in a well-defined umbilicus; *fruit* rather small (mean length, 1 to 2 centimeters; thickness, 1 to 1¼ centimeters). *Form* almost oval, slightly elongated; very slight swelling on one side; deep black with abundant bloom. *Skin* thin; *pulp* abundant, fleshy, with a deep wine-red juice; *pit* large, being the same shape as the berry; *maturity* medium.

This variety is quite delicate and very sensitive to cold, hence is not found in very old plantations in Europe, having been killed off during the very cold seasons that sometimes occur. It is moderately productive, and bears a crop almost every year when properly adapted to the climatic conditions.

The quality of its oil is excellent.

Analysis of Atrorubens.

	France.	California.
Number of olives in 100 grams	41	28
Percentage of pit in whole fruit	22.15	16.75
Percentage of flesh in whole fruit	77.82	83.25
Percentage of oil contained in fresh flesh	17.91	22.85

The above analyses show that the average Atrorubens in California is a larger and richer olive than in Europe. It has less pit, more flesh, and this flesh contains more oil. From data thus far at hand we are led to believe that it is more prolific in California than in France. The above figures are averages of four analyses of olives grown near Montpellier, France, and two analyses of olives grown at Biggs and Fresno, California, respectively.

AMELLAU.

SYNONYMS: *Amenlau, Amenlaou, Amellenque, Amandier, Amellaude; Olea europea amygdalina* (Gouan). *Olea sativa, major oblonga, angulosa, amygdaliforma.*

TREE not vigorous, rarely reaching an advanced age. Semi-erect *grower*. *Trunk* small, twisted, frequently irregular; *foliage* slightly drooping; the general aspect of the tree is that of a ball; *suckers* very numerous; *branches* short, erect, or horizontal, not vigorous. Young branches generally horizontal, of an ashy-gray color; *bark* reddish; *wood* irregularly flattened at its extremities; *eyes* prominent.

LEAVES both short and wide (mean length, 4 to 6 centimeters; width, 1 to 1½ centimeters); upper surface olive green; lower surface with very slight silvery white deposit; nerves prominent on the superior surface only; *petiole* large, short, slightly bent over. The leaf is almost flat. The tree is but thinly covered with leaves.

FRUIT nearly always single, irregularly distributed; *peduncle* large, short, inserted in a deep depression in the olive; *stigma* hardly apparent; *fruit* very large (mean length, 2½ to 3 centimeters; thickness, 1½ to 2 centimeters), of irregular form, recalling that of the hull of a green almond (whence its name). It is more or less flattened, and has a prominent ridge passing over its two ends. The olive passes from a clear green to a very deep reddish-black, with considerable bloom, and a number of small whitish specks. *Pit* very large, irregular, with a depression at one end. *Maturity* medium early.

This is a Southern French variety. It bears a very large berry, which makes it valuable for pickles; but on the other hand it is not productive in its native country, though in California it is said to be somewhat more prolific. It bears the greater part of its fruit on the *erect* branches of the secondary growth, thus requiring a different system of pruning from the other varieties. In Europe the fruit is picked green for pickles; but yields a small quantity of high-grade oil.

Analysis of Amellau.

	France.	California.
Number of olives in 100 grams	20	19
Percentage of pit in whole fruit	18.10	16.00
Percentage of flesh in whole fruit	81.90	84.00
Percentage of oil contained in fresh flesh	15.40	17.50

From the foregoing comparative tables it will be seen that at Biggs, in Butte County, California, the Amellau does better than the average of the same variety in France, the olive being larger, having less pit, more flesh, and 2.10 per cent more oil.

There was but one sample of this variety received at the University for analysis. This was donated by Hatch & Rock, of Biggs. It is desired to have samples of this variety from other localities.

MANZANILLO.

SYNONYMS: *Manzanilla, Rojal, Olea europea pomiformis* (Clemente), *Ampoulleau* (France).

The Manzanillo is one of the best varieties thus far introduced into California. It is a good bearer, quite regular in its crops, and at the same time equally well adapted for pickles or oil-making. This last quality gives it the advantage over other varieties for the small grower who cannot afford to make his own oil and wishes to be independent of the mill-owner. While it does well in many kinds of soils, it will not thrive in very dry shallow land; here, as in its native country (Spain), it requires plenty of moisture and a good strong soil. There seems to be more than one kind of Manzanillo now found in the orchards of the State. Though these certainly differ one from the other, there seems to be no good reason for attempting to rename these variations from the main type at the present moment, for the differences are unimportant and as yet not well studied.

TREE vigorous and hardy; *branches* long, curved, and light-colored. The secondary branches or twigs dry up when the fruit falls, which is very frequent.

FRUIT large and apple-shaped, sometimes slightly elongated. The chief difference thus far noted between the various kinds of Manzanillo is that in some cases the apple-like depression at the lower extremity of the fruit is more marked than in others, otherwise there seems to be little real difference.

It is found throughout Spain and in South France, where we are told it requires frequent regular pruning to insure regular crops.

Analysis of Manzanillo.

	Spain.	California (Average).
Number of olives in 100 grams	15	21
Percentage of pit in fresh fruit	12.50	16.10
Percentage of flesh in fresh fruit	87.50	83.90
Percentage of oil in fresh flesh	----------	* 22.57

* Average of five lots.

From this comparison it will be seen that the Manzanillo does better in its native country than in California, so far as size is concerned; but we must bear in mind that the figures for California are made up of analyses of olives from many and all sorts of localities, while in Spain the variety has been long adapted to the soil that suits it best. Reference to the table will show that there are localities in California where the Manzanillo does fully as well as in Spain. There seems to be a difference in the minds of many growers as to the value of the Manzanillo. While in one locality it does remarkably well it has been found that in others, quite near, it is very irregular. As it is a variety extensively planted in California, this has led to lively controversies. Of course all varieties of olives must be adapted to special circumstances; and when the Manzanillo has been well placed, it would seem to be one of the best varieties to plant. It will certainly not do everywhere, but does not seem to be any more difficult of adaptation than any of the other varieties.

ROUGET (OR CAYON IN CALIFORNIA).

SYNONYMS: *Rougette, Rousseoun, Marveilletto, Pigan, Vermillau, Caillose, Cayonne, Rougealle; Olea rubicans* (Rozier).

This variety is known in California under the local name given it in the Toulon district, but as it is a well-known Languedoc variety, we shall follow the Languedoc nomenclature, as do the eminent authorities, Foëx, Viala, Flahaut, and Degruilly, of the National School of Agriculture at Montpellier, France.

TREE vigorous, attaining very large dimensions when favorably situated; *trunk* cylindrical; semi-erect grower; *bark* rough, and of a blackish gray color; *suckers* very numerous; *foliage* very plentiful, even on the old wood; vigorous, long, slender, and for the most part horizontal, or semi-erect; of a dull gray color; *eyes* prominent.

LEAF medium short and wide (mean length, 5½ to 6½ centimeters; mean width, 1 to 1¼ centimeters). Superior surface of leaf is dull green, with speckled edges. Inferior surface has a slight greenish deposit; *nerves* not prominent on either surface. The leaves are very numerous, forming a thick covering to the tree, inserted perpendicularly, and presenting only the upper surface to the view. This, together with the dark green color of the leaves, makes it easily recognizable from a distance.

FRUIT distributed evenly over the tree on the two-year-old wood, perhaps more abundantly at the base; single or in groups of 2, 3, or 4; *peduncle* medium long and thick, inserted in a slight depression; *stigma* not very well marked; *fruit* under the the medium size (mean length, 1½ to 2 centimeters; mean width, 1 to 1¼ centimeters); oval in shape, with slightly flattened ends. The fruit remains red for a long time, and even when it turns black there are numerous red specks on

the surface. *Skin* is quite shiny, with little bloom. *Flesh* is abundant, and slightly wine-colored. *Pit* is medium-sized or small. *Maturity* quite late.

The Rouget is a very hardy variety, and is especially adapted to soils of a poor quality. It is found in dry rocky localities where all other vegetation is impossible. Ordinarily the tree attains large dimensions, and yields good regular crops, even when not favorably located. In Europe the coldest seasons never affect it. The Rouget yields oil of very good quality; it is also used for pickling, for which purpose it is picked when red.

We have no record of analysis of this variety from California. It is to be hoped that all those who have the Rouget or Cayon in California will send in samples for experiment.

Analysis of Rouget.

	France.
Number of olives in 100 grams	45
Percentage of pit in whole fruit	20.00
Percentage of flesh in whole fruit	80.00
Percentage of oil in flesh	15.27

From this analysis, it would seem that in France this variety yields much less oil than most of the varieties in California; but as we have shown, this is no test of its value in California, for others, which in Europe do no better than this, have proved to be most excellent in California.

PLEUREUR (CAILLET).

SYNONYMS: *Caillet, Cayé, Caillette,* or *Cayette* (Provence); *Cayon* (Herault); *Nostrale* (Nice, France, and Santa Barbara, California); *Olivier de Grasse* (Bernard).

Confused with the Pendoulier in some places under the names *Olivier pleureur, Cournaud, Cormaou.* We are led to believe that what we have in California under the name of Pleureur de Grasse is none other than the Caillet; so in order to avoid all possible confusion we accept the name Pleureur, provisionally.

TREE large and vigorous, pyramidal grower; *trunk* thick and cylindrical; *bark* dull gray; *suckers* numerous; *foliage* very abundant and vigorous, inserted at right angles, falling toward the ground after growing a few inches. Three years after pruning these branches become long enough to resemble those of the Pendoulier. Color of the young branches is light gray, turning to a dark gray with age.

LEAF medium or large (mean length, 6½ to 8 centimeters; width, 1 to 1½ centimeters); superior surface very dark green; inferior surface with very little greenish deposit; principal nerve very apparent on the superior surface; *petiole* short.

FRUIT regularly distributed, single or frequently in pairs, in which case the pedicle is long; *peduncle* medium, tolerably thick, dull green, inserted in a very slight depression in the berry. An olive of medium or above the medium size (mean length, 2½ centimeters; thickness, 1¼ to 1½ centimeters); *form* elongated ovoidal, slightly flattened at one side and swollen on the other; larger at the extremity, which is obtuse. *Color* violet black, with very little bloom; *skin* tender, shiny; *pulp*

fleshy, colored by a violet juice. *Pit* large and of the same form as the olive, but more pointed.

The Caillet, or, as we shall call it, the Pleureur, is one of the most widely and extensively cultivated varieties of the Department of the Alpes-Maritimes. In the neighborhood of Grasse and Nice, it is the only variety now planted in the new plantations, or in place of trees accidentally killed. It is a remarkably vigorous grower, and in the neighborhood of Nice the trees have reached an extraordinary size, being as large as forest trees. It is a good bearer, and yields an oil of the very best quality. We have no records at hand as to this variety in California, but there is every reason to believe that it will do fully as well in this State as in the Riviera.

The Nostrale of Nice, France, was imported by the late Dr. Hall, D.D.S., of Carpinteria. We are led to believe that this variety is none other than the Pleureur. It seems to thrive excellently in Santa Barbara County, where we hear of several plantations. It should be cultivated especially for the quality of its oil.

PENDOULIER (CORNIALE).

SYNONYMS: *Corniale; Cornal, Cournal, Courniale Lucques Batarde* (Montpellier); *Courniaou, Cornaou* (Languedoc), *Courmeau, Corniau, Gourgnale, Plant de Salon; Courneaud, Cournial, Couchesal* (Gard); *Taglasca* (Genoa), *Pendulier* (La Ciotat, Var); *Salonenque* (Marseilles); *Oliva Cornicabra* (Tablada); *Olea Europea Rostrata* (Clemente).

TREE very vigorous, growing very large under favorable circumstances; its characteristic manner of growing recalls that of a weeping willow tree; *trunk* large and cylindrical; *bark* grayish black; *branches* generally inclining toward the ground. Young branches long and slender, falling perpendicularly toward the ground. Seen from a distance, it has the aspect of a weeping willow tree; *suckers* always very numerous; *foliage* when young, very long and slender, and numerous, inserted at right angles, but falling perpendicularly toward the ground. The color of the young branches is ashy gray, changing to a clear yellow, and afterwards passing to green on the older foliage. *Eyes* very prominent.

LEAF oval, elongated, narrow at the summit (mean length, 6 to 8½ centimeters; width, 1 to 1½ centimeters). Upper surface clear, shiny green; lower surface has a slight deposit of silvery gray color. The leaves are very abundant, and the covering of the tree is quite thick. The leaves are sometimes twisted on their petiole so as to expose the lower surface to the view.

FRUIT regularly distributed over the foliage, sometimes single, sometimes in groups of two and three, and in some cases even in bunches of five to six; *peduncle* long, slender, clear green, inserted in a depression that is not well marked; *stigma* and umbilicus not very apparent.

DRUPE of medium or more than medium size (mean length, 2¼ to 2¾ centimeters; width, 1 to 1¼ centimeters); irregular in form, recalling that of the dogwood berry, narrower at the top, slightly swollen on one side, and arched at the other, terminating abruptly in an obtuse point. The fruit passes from red at maturity to deep black; very little bloom; *skin* very shiny, slightly specked, and tender; *pulp* fleshy, abundant; *juice* reddish; *pit* large as compared with the size of the whole fruit; shape of pit about the same as the olive, but slightly more pointed. Variety is of the second period of maturity, *i. e.*, medium early.

The Pendoulier, or Corniale, as it is generally known in France, is without doubt one of the most attractive olives of the Old World. It is known in California by its synonym on the Riviera; hence, we adopt that nomenclature to avoid confusion. Though it never forms plantations by itself, it is found throughout Southern France. It is an abundant bearer and quite regular in its crops. Although it is a vigorous and hardy tree, yet it prefers good soils to a stony shallow soil. It yields oil of superior quality, and like the Pleureur, deserves attention.

Analysis of Pendoulier.

	France.
Number of olives in 100 grams	58
Percentage of pit in whole fruit	24.60
Percentage of flesh in whole fruit	75.40
Percentage of oil in flesh	15.00

It is to be regretted that we were unable to obtain samples of this variety for experiment, for it is one of the most important and highly esteemed varieties of France, valued especially for the great delicacy of its oil.

PICHOLINE (TRUE PICHOLINE OF EUROPE).

SYNONYMS: *Pichouline, Pijouline* (throughout the Languedoc); *Saurine* (at Nimes); *Sausen, Saugen, Sauzin* (in the Department of Gard); *Saurenque* (Aix-en-Provence); *Plant de Sauren, Saurine, Punchado* (Marseilles); *Lucques Batarde* (Herault); *Pignola* (Genoa, Italy).

TREE of medium vigor and dimensions, spreading grower; *trunk* cylindrical; *bark* detaches easily from the trunk in irregular strips; *branches* grow horizontally, or with a slight upward inclination; very few suckers; *foliage* not vigorous, thick, growing at right angles to the main stem; of a yellowish-gray color; *wood* cylindrical or slightly flattened; *eyes* prominent.

LEAVES oval, frequently wider at the upper part; medium length, and above medium width (5½ to 6½ centimeters in length, 1½ to 1¾ centimeters in width). Upper surface dull, deep green; lower surface with slight dirty-white pubescence; well marked nerves on lower surface; *peduncle* thick, long, straight. The leaf is flat at the edges. Young branches are heavily covered with leaves.

FRUIT generally accumulated near the lower part of the wood of the year, single or in bunches of two. *Pedicels* very short; *stigma* persistent in a very slight umbilicus. *The fruit is above the usual size* (mean length, 2½ to 3 centimeters; width, 1 to 1½ centimeters). The form is ovoidal and elongated, but thickest near the peduncle, coming to a point near the lower extremity. It is very much *curved*, of a form intermediate between that of the Lucques on one hand and the Olivière on the other. The fruit passes from a clear green to a reddish-black; very little bloom, thin skin. *Pit* small, long, and pointed, being of the same shape as the fruit; maturity medium.

The true Picholine is widely known in France, especially in the neighborhood of Aix, Tarascon, and Marseilles, and throughout the Languedoc. It yields good crops with tolerable regularity. It is a variety of medium hardiness, but stands very heavy pruning. In France it is *cultivated chiefly* for pickles, although it yields a fair amount of high-

grade oil. Its great delicacy makes it highly esteemed for pickles, being generally sold under the name of Lucques. It and the Verdale are the best eating varieties of the country.

In California the general belief seems to be that it is the same variety as the Oblonga. There is certainly a strong resemblance between the two, but we are not as yet ready to classify the two as identical. Below we give a comparative analysis of the Picholine made in Europe and the California Oblonga. From the figures alone I think it will appear sufficiently distinct to be classed by itself, knowing as we do, that in California we should look for larger fruit and more oil than in Europe.

Analysis of Picholine.

	Picholine, France.	Oblonga, California
Number of olives in 100 grams	23	40
Percentage of pit in whole fruit	10.86	19.00
Percentage of flesh in whole fruit	89.14	81.00
Percentage of oil in flesh	17.00	17.02

Aside from botanical differences, the analysis shows it to be unwise to call these two the same variety until the subject has been further investigated. It can be readily seen that it is distinct from the Redding Picholine, though some people are still found who claim that the Redding Picholine is the true Picholine of Europe. This error is so preposterous that no further attention need be paid to it.

VERDALE.

SYNONYMS: *Verdaou, Verdau, Vereau, Aventurier, Classen, Olea Viridula, Olea Media, Rotunda Viridia* (Tourneford), *Olivo Verdago* (Tablada).

TREE not vigorous, always remaining small; semi-erect grower; *trunk* slender, short, conical; *bark* reddish gray-green; shallow penetrating *roots*, hence frequently uprooted by winds; *suckers* few; grafts easily; *branches* not plentiful, erect or slightly inclined, growing at right angles; *color* dirty yellow, or clear green; *eyes* medium prominent.

LEAVES short, narrow (mean length, 4 to 6 centimeters; width, $\frac{1}{2}$ to $\frac{3}{4}$ centimeters); edges folded over, forming a trough; *nerves* prominent and of a clear green color; *petiole* short, slender, and twisted. All the leaves grow on the same plan, and form with the stems a very acute angle. The leaves are abundant at the extremities of the branches, but very scarce on other parts of the tree.

FRUIT single, never in clusters; *peduncle* medium length, slender, and dirty green; very slight depression in fruit for insertion of peduncle; large fruit, nearly round, slightly truncated at the summit; very green up to the period of maturity, then wine-red, and finally a deep black; very slight bloom at maturity; thick *skin*, fleshy, very little juice in berries; *pit* very large, of same shape as the fruit, with deep longitudinal furrows.

This is a Languedoc variety found throughout France, and highly esteemed for pickles; maturity very early. It is little used for oil, as the quantity of oil yielded is very small, and the berries rot very easily. It requires good, deep soils, and will not do at all in poor soils. It is attacked by frost, and is subject to "coulure," or the dropping off of the young fruit just after blossoming.

Analysis of Verdale.

	France.
Number of olives in 100 grams	38
Percentage of pit in whole fruit	17.70
Percentage of flesh in whole fruit	82.30
Percentage of oil in flesh	22.83

None of the trees at the Culture Stations are yet in bearing, and we know of no bearing trees in the State, hence we have no data for comparison. It is earnestly requested of those having this variety in this country to send samples to the University for analysis; also any data concerning its growth, etc.

ROSE.

SYNONYMS: None known.

TREE medium vigor, medium development, spreading grower; *trunk* cylindrical; *bark* grayish.

LEAF elongated, oval lanceolate, medium sized (mean length, 6 to 7 centimeters; width, 1¼ to 1½ centimeters); superior surface shiny dark green; inferior surface greenish white, with a very slight deposit; *blade* thick, with slightly folded edges; one principal *nerve* well marked on both faces. The leaves are not very numerous and the covering of the tree is not very thick or heavy. The leaves are so twisted on the petiole as to stand off perpendicularly to the branch that bears them.

FRUIT: This variety bears its crop only at the base of the branches, either singly or in bunches of two and three; *peduncle* long or medium, inserted in a deep depression in the olive; *stigma* hardly apparent. An olive of medium or large size (length, 2¾ centimeters; width, 1½ centimeters). *Form* cylindro-conical, but flattened at one side and terminating in a point not at all sharp or long. The fruit passes from a red to a reddish-black color; slightly specked, and little bloom. *Skin* thin, *pulp* whitish, slightly colored by a rose-colored juice; *pit* large, of a form more elongated than the olive itself and sharper pointed. *Maturity* medium late.

This variety is but little cultivated in the Languedoc. It is a good bearer and quite regular in its crops. It is mostly used for pickles. It is not yet in bearing in California, so far as we know.

EMPELTRE.

SYNONYMS: None known.

This is a Spanish variety, of dwarfish habits; so named because of the remarkable ease with which it may be grafted, it being seldom, if ever, grown on its own roots. The word *empeltre* signifies "grafted." This variety is not widely known in Spain on account of its want of vigor, but is esteemed on account of the rapidity with which it comes into bearing, and its resistance to cold, which enables it to grow on the extreme limits of the olive regions in Spain.

TREE is not at all vigorous.

LEAVES are short and unevenly divided by the main nerve, which is not at all prominent and quite fleshy; superior surface is dark green; inferior surface is light green with a slight white deposit.

FRUIT bell-shaped, medium-sized (mean length, 28 millimeters; thickness, 16 millimeters); *pit* is free from the pulp, and small.

This variety is equally well suited for pickling or oil-making, yielding an oil abundant in quantity and of very good quality. It is a rapid grower, yielding its crops sooner than any of the other varieties. It is a regular bearer, requiring a rich loose soil. It should be pruned annually, but very slightly each time.

So far as we know there are no bearing trees of this variety in California. Though we have seen trees supposed to be of this variety in Southern California, we cannot agree with the growers as to what they are. It is beyond dispute that the true Empeltre is a *dwarf*. The trees we saw were as large as the Mission. The only analyses we have are those made in Spain.

Analysis of Empeltre.

	Spain.
Number of olives in 100 grams	20
Percentage of pit in whole fruit	20.00
Percentage of flesh in whole fruit	80.00

LECCINO, OR LECCIO.

This is a very hardy Tuscan variety that resembles the wild olive in the manner of its growth. From a distance it looks like a scrub oak (*Quercus ilex*), whence its name. It is one of the oldest varieties which we are able to recognize, being accurately described by the ancient Latin authors. Its twigs are very robust, rigid, long, and not much ramified. It resists the cold in a remarkable degree, having withstood the very low temperature of 12° (F.), which is fatal to almost all other varieties. It sets its fruit well, and never drops the crop after setting. It does especially well compared with other varieties on the coast where there are damp cold sea-winds. The fruit is almost as large and fleshy as the Grossajo, but much less rich in oil. We have no record of this variety in California, though it is grown at most of the Culture Stations.

While it is a hardy grower, and good bearer, it yields an oil that is prone to be cloudy and hard to clarify; besides being of an inferior quality as regards taste.

RAZZO, OR FRANTOJANO.

This variety is mainly cultivated in the provinces of Lucca and Pisa, together with Mignola, Morajolo, Puntarolo, and Grossajo. The twigs of the Razzo are short, light-colored, numerous, and slightly drooping.

It is the practice, in the home of this variety, to prune it less than the others, probably on account of its being a less vigorous grower. Its leaves are narrower at the insertion than at the apex; bright green on the upper surface, and has a heavy, white tomentum on the lower surface. The soils that suit it the best are those that are deep, rich, and well drained. It suffers from cold fogs and winds of the lowlands, preferring the protected hillsides. Though it is exceptionally fertile, it drops its fruit very readily, especially when exposed to winds or to

prolonged hot spells. The fruit is roundish, fleshy, and contains more oil (in Italy) than any of the native Italian varieties, on which account it is called by the peasants "frantojani" or oil-press olive. In California, however, it does not yield so much oil as the Grossajo. The Razzo commences to ripen in November or December.

Thus far, we know of it bearing at but one place in California, "El Quito Farm," in Santa Clara County, though it is grown at all of the University Experiment Stations since quite recently.

Analysis of Razzo.

	California.
Number of olives in 100 grams	52
Percentage of pit in whole fruit	30.00
Percentage of flesh in whole fruit	70.00
Percentage of oil in flesh	33.70

THE MISSION OLIVE.

By this name is designated the variety found growing at the old Missions in California. Samples of the fruit sent to Don José de Hidalgo Tablada, a noted Spanish authority on the olive, led to the classing of our mission varieties with the Cornicabra-Cornizuelo (Synonyms: *Olea Europea Rostrata* of Clemente; *Olivo Crasiomorpha* of Gouan; *Cournaud, Corniaud, Plant de Salon, Plant de la Fane, Cayon, Plant d'Entrecasteaux, Rapunier, Olivier de Grasse, Cayonne,* etc.). However true this classification may be, it is certainly true that under the name of Mission is embraced many varieties differing slightly the one from the other; and also that by reason of the long time this variety (or varieties) has existed in California, a great change has taken place in the original characteristics, due to differences in soil and climate. This change of character in varieties of grapes brought from the same countries has been noted; and as soon as the olive industry has been as carefully studied, it will be found that there is little use in referring the Mission back to the original variety which the old Mission Fathers brought out from Europe nearly three hundred years ago. To all intents and purposes the Mission is a new variety differing from anything found in the Old World. It remains for us to pick out the various varieties of Mission and rename them without regard to European origin. This renaming is not advisable in the other cases, for the varieties are of such recent importation that there has not elapsed sufficient time for the influences of soil and climate to modify very sensibly the characteristics.

Common, or Broad-Leaved Mission.—This is the commonest form of the Mission in California. Fruit $\frac{13}{16}$ of an inch long by $\frac{10}{16}$ of an inch thick; ovate oblique—sometimes very much so—the pit straight or slightly curved, $\frac{10}{16}$ of an inch long and $\frac{5}{16}$ of an inch thick; variable in size, single or in clusters of two or more; ripens late on the coast region, sometimes not till February, but generally in December, in warmer localities in November.

Other Mission Varieties.—On the University grounds there are now being studied three apparently distinct varieties of the Mission: (*a*) *Broad-leaved* or *Common Mission*, already described; (*b*) *Narrow-leaved*

Mission, a variety from L. A. Gould, of Auburn, described as having a somewhat larger fruit than the broad-leaved variety, and a more straggling habit; (*c*) *Early Mission*, from A. A. Wheeler. It is of the Mission type, but ripens much earlier.

Whatever be the differences, these are of the same type and are so very much mixed and confused that in this article we shall have to call them all Missions.

Analysis of Thirteen Samples of Mission.

	California.
Number of olives in 100 grams	30
Percentage of pit in whole fruit	19.60
Percentage of flesh in whole fruit	80.40
Percentage of oil in flesh	22.94

From this result it will be seen that the Mission is a good average variety. Reference to the table will show that in no locality does the oil yielded fall below 19.20 per cent, which for some of the other varieties is a good maximum; also, it will be noted that the size of the fruit is such as to render it fit either for pickling or for oil-making; while the experiments in the oil-room at the University show it to yield an oil that has better marketable qualities than most others. Its easy adaptation ought to commend it to all who are in doubt as to the special variety to be planted on new and untried soils. Careful comparative observation shows that it really is no more irregular than the other varieties. There are more localities where it has proved to be irregular, because there are at least ten localities where Missions are grown to one where other varieties grow.

REDDING PICHOLINE.

This was imported from France by the late B. B. Redding. It was imported for the large pickling olive known in France as Picholine, and very highly esteemed there for that purpose, as well for the small quantity of high-grade oil it yielded. For a long time it was supposed that the Redding Picholine was after all the true Picholine of Europe. Reference to the description of the true Picholine will show that this is an error. To-day the Redding Picholine is very widely planted in California, and, by many, is highly esteemed on account of its abundant crops and very vigorous growth. While it yields oil abundantly, the latter is of an inferior quality on account of the extreme difficulty of maintaining it clear and brilliant. The oil-room experiments showed it to be the most difficult in this respect. It solidifies very easily and is hard to clarify. From samples of Redding Picholine oil as seen at the Columbian World's Fair in Chicago and also at the California Midwinter Fair, these observations were proved to be correct; the oil being prone to deposit a white granular, "lardy" sediment after a short time.

FRUIT is perfectly oval in shape, $\frac{8}{16}$ of an inch long and $\frac{4}{16}$ of an inch thick; ripens early, several weeks sooner than the Mission; is dark purple or black in color; in pickling the pulp loses its bitterness quickly, the fruit being pleasant to the taste.

Analysis of Six Samples of Redding Picholine.

	California.
Number of olives in 100 grams	79
Per cent of pit in whole fruit	24.42
Per cent of flesh in whole fruit	75.58
Percentage of oil in flesh	24.65

From this, taken with the complete analysis in the large table given below, it will be seen that the exceptionally small size of the fruit and the very high percentage of pit in the whole fruit makes it a variety not at all adapted to pickling, while the oil-room experiments show it to be a very poor oil variety. The reason that it gained such a foothold in the plantations of this State seems to be that it was supposed to be the true Picholine of Europe, a variety held there in high esteem. It was planted very extensively before the true nature of the variety was discovered. With all its defects it is an abundant bearer, and is very vigorous, hence very well adapted as a stock for grafting the more feeble varieties.

Several oil-makers have, after careful experiment, decided to mix no more Redding Picholine oil with that of other varieties, for the reason that they consider that the keeping and marketing qualities of the mixture is injured by so doing.

It has been noted that the quality of oil made from this variety is much better on gravelly hillsides than on richer bottom land. On a rich soil the oil yielded is especially bad, not only as regards keeping qualities, but in taste also.

While the present limited supply of pure California oil enables that made from this variety to find a ready market, growers must remember that this state of affairs will soon change and only the best will be called for. The tree is such an excellent grafting stock that it can be readily grafted into just as prolific varieties which do not have the same faults.

For those intending to change the variety, we recommend trying the combination graft and bud. Use a regular grafting scion inserted in the usual way practiced in budding. This has been found by some nurserymen to be better than grafting proper, or the usual method of budding.

RUBRA.

SYNONYM: *Caillon (?).*

This was imported from France by John Rock, of Niles. It is somewhat like the Mission in general appearance; *fruit* ovate, slightly oblique, smaller than the Mission, $\frac{12}{16}$ of an inch long, $\frac{8}{16}$ of an inch thick; *pit* straight, pointed, $\frac{8}{16}$ of an inch long and $\frac{4}{16}$ of an inch thick; *maturity* early, ripening from three weeks to one month earlier than the Mission; jet-black in color when allowed to hang on the tree. The tree begins to bear early and is quite prolific.

Analysis (average) of Nine Samples of Rubra.

	California.
Number of olives in 100 grams	40
Percentage of pit in whole fruit	17.80
Percentage of flesh in whole fruit	79.94
Percentage of oil in flesh	22.28

By reference to the general table it will be seen that the Rubra is, when well adapted to soil and climate, an excellent variety for oil, as it yields as high as 34 per cent in some cases, and of superior quality. The chief defect of this variety seems to be that it is more variable than any of the other varieties tried at the University Experiment Station, the variation between maximum and minimum being as high as 20 per cent in oil contents. It seems to do badly in low rich bottom land, and best in poorer soil. At Newcastle, where the highest percentage was reached, the soil is of granitic formation, not at all rich, but high, and well drained.

There seem to be several varieties called Rubra in this State. We have not been able to identify it with any well-known European variety on this account.

REGALIS.

This was imported from France by John Rock, and is quite extensively known in California. *Form* almost perfectly round, oval, dark purple or black; large, $1\frac{1}{16}$ inch long by $\frac{13}{16}$ of an inch in thickness; *flesh* firm; *pit* $\frac{9}{16}$ of an inch in length by $\frac{5}{16}$ of an inch in thickness, generally straight, square at the base, pointed at the apex; ripens slightly ahead of the broad-leaved Mission variety.

Analysis of One Sample of Regalis.

	California.
Number of olives in 100 grams	34
Percentage of pit in whole fruit	22.00
Percentage of flesh in whole fruit	78.00
Percentage of oil in flesh	21.60

We regret that no more samples were obtainable for analysis at the Station, as this variety is very highly spoken of by many; but it would be unwise to judge of it from but one analysis. We do not know what the European name of this variety is, as great confusion is noted. All those who are able are requested to furnish the Station with what data they can.

COLUMBELLA.

This was imported from France by John Rock, of Niles. General *form* broadly oval, $\frac{14}{16}$ of an inch long and $\frac{11}{16}$ of an inch thick; very even in size, remarkable for the peculiar pale-yellow color the fruit assumes before turning purple; *pit* small, $\frac{8}{16}$ of an inch long and $\frac{5}{16}$ of an inch in thickness, straight and sharp-pointed; the *pulp* seems to part with its bitterness slowly, but when properly prepared it has a delicious flavor. It ripens late, some time after the broad-leaved Mission.

Analysis (average) of Five Samples of Columbella.

	California.
Number of olives in 100 grams	41
Percentage of pit in whole fruit	18.00
Percentage of flesh in whole fruit	82.00
Percentage of oil in flesh	18.77

From these analyses it will be seen that the Columbella is not very rich in oil, though the quality of its oil is very good. We have been unable to find out under what name this variety is grown in Europe. It is sometimes called Columella, but Columbella seems to be the most popular name.

OBLONGA.

This was imported from France by John Rock, of Niles, Alameda County. It is an olive of peculiar club-like shape, being narrow at the stem end, broad at the end, rounded, and strongly oblique, $\frac{1}{16}$ of an inch long and $\frac{8}{16}$ of an inch thick. *Pit* is curved, $\frac{11}{16}$ of an inch long by $\frac{4}{16}$ of an inch thick, and generally pointed at both ends. The *pulp* loses its bitterness comparatively quickly in pickling, and is very pleasant tasting, which recommends it especially as a pickling variety. It ripens at least two weeks earlier than the common broad-leaved Mission. *Color*, dark purple.

It is commonly supposed that the Oblonga is the same as the true Picholine of Europe. There seems to be little foundation for this belief, as the two varieties are quite distinct. We are uncertain as to the true name of this variety.

Analysis (average) of Six Samples of Oblonga.

	California.
Number of olives in 100 grams	40
Percentage of pit in whole fruit	19.00
Percentage of flesh in whole fruit	81.00
Percentage of oil in flesh	17.02

From this it will be seen that the Oblonga is not one of the best varieties for oil-making, although the quality of its oil is very good. The delicate flavor of its flesh renders it adapted for pickling; although the percentage of pit in the whole fruit is not especially small, yet it is not too great, and the size of the olive is fair. One of its peculiarities seems to be that the quantity of flesh diminishes very much during the process of pickling, so that when pickled the percentage of pit in the whole fruit seems to be much greater than the table would indicate.

LIST OF OLIVE VARIETIES PLANTED AT THE STATIONS.

There are at present planted at the five Experiment Stations of the University of California the following varieties:

1. Amellau.
2. Ascolano No. 1.
3. Ascolano No. 2.
4. Ascoli.
5. Atrorubens.
6. Atroviolacea.
7. Bella de Spagna.
8. Belmonte.
9. Cayon or Rouget.
10. Champion.
11. Columella.
12. Corregiola.
13. Cucca or Cucce.
14. Dalmatian.
15. Empeltre.
16. Frantoio or Frantojano.
17. Grossaia (Grossajo?)
18. Grossayo (Grossajo?)
19. Gentile.
20. Hervaza.
21. Hispania.
22. Huff's Spanish.
23. Infrantojo.
24. Lavagnino.
25. Leccino.
26. Lucques.
27. Macrocarpa.
28. Mission, Nos. 1, 2, 3, and 4.
29. Mignollo.
30. Morchaia.
31. Morinello.
32. Nevadillo Blanco.
33. Nigerina.
34. Obliza.
35. Oblonga.
36. Olivastro.
37. Oriola.
38. Palazzriolo.
39. Pendulina.
40. Pendoulier.
41. Piangente.
42. Picholine.
43. Pleureur.
44. Polymorpha.
45. Praecox.
46. Razzo.
47. Redding Picholine.
48. Regalis.
49. Rosselina.
50. Rubra.
51. Ruffa.
52. Salonica.
53. Santa Catherina.
54. Uvaria.
55. Verdale.
56. Becca Ruffa.

TREE OF THE OBLONGA OLIVE, 10 years old.

While we have attempted to describe only those varieties of which there are descriptions extant, we purpose to continue this work of classification and description till all on this list have been thoroughly studied. It is hoped that any one having any data (information as to importation, samples of fruit, etc.) will take the earliest possible opportunity to communicate with the Agricultural Experiment Station at Berkeley, so that this work may not be delayed. It is only by such methods that we can ever hope to gather all information desired.

A NEW DISEASE OF THE OLIVE TREE.

My attention has been called to a new disease affecting the leaves of the olives, in various parts of the State. After careful microscopic examination I have, I think, identified it as a fungus described in Europe as *Cycloconium oleaginum*. This fungus was first described by Castagne, later by von Thümen and others; more recently and completely it has been studied by Monsieur G. Boyer, of l'Ecole Nationale d'Agriculture de Montpellier, France. It is from his valuable study that I make the following brief observations:

Up to the present time it was commonly conceded that this fungus existed only on the olives of France; its presence having been noted only on the olives in that country. It lives on the two faces of the leaf, though sometimes found on the peduncle and fruit also. On the upper surface of the leaf, where it is most commonly found, it forms circular spots, frequently blackish in color, sometimes gray or brown, the centers of which usually are of a different color from the surrounding surfaces of the circle. The majority of these discolored spots are from six to ten millimeters in diameter, though on large-leaved varieties they may be fifteen and more millimeters in diameter. The spots are irregularly distributed over the blade of the leaf, in numbers varying with the intensity of the disease. The *Cycloconium oleaginum* appears on the leaves at all seasons of the year; even on the same leaf one sometimes finds it in all stages of development. It usually, however, makes its appearance at the end of summer or in autumn. The color of the spots is usually blackish at first, fading to brown or gray, the rest of the leaf becoming quite pale-green or yellow, thus defining them quite well from the unaffected parts of the leaf. Von Thümen compared them to the spots or "eyes on the feathers of a peacock's tail."

Monsieur Boyer was the first person to note the presence of the fungus on the peduncle and fruit. He noted that in this location the fungus produces isolated or confluent spots that preserve a uniformly blackish color throughout their existence. The narrow spots are on the median nerve of the leaf, usually covering its entire length. Young or partly developed leaves never show the spots, only fully grown leaves being attacked. Microscopic examination shows that this blackish coloration of the affected parts is due to the presence of innumerable black spores. As these become fully developed and blow away, the color becomes lighter, as previously noted.

The reason the disease is not found on the branches is because the epidermis scales off during the second year and the fungus cannot penetrate the layer of cork that covers the bark.

The fungus sometimes develops on the leaves of the olive quite abundantly, rarely on the fruit. It seems to prefer certain varieties, such as the Lucques, Amellau, Rouget, and Verdale. In California I have found it only on the Mission, but thus far I have been unable to make extended search for it. As its development on the fruit is very late, there is nothing whatever to fear in this regard. On the leaves its development is so very slight, and the damage caused is so insignificant, that it is a disease not likely ever to become of sufficient importance as to require treatment of any sort. The only reason for mentioning it in this place is that many have noted its presence and were fearful lest it might be some new and dangerous disease; which is not the case.

OLIVE CULTURE.

Perhaps one of the reasons that the olive seems more vigorous in California than the same variety in Europe is that here we have no "mixed crops" of olives, grain, potatoes, etc., and that we plant the olive on the best soil we have, instead of on the poorest. It is certainly true that in California the olive is a more vigorous and prolific tree than in the Old World. Not only do the trees attain larger dimensions, but the yield of oil and fruit is greater for trees of the same age than elsewhere. While it is certainly true that the olive will live and bear fruit on a very poor soil, it is incontestable that the tree thrives better and prefers a rich soil. By rich soil we must not understand black adobe bottom, or rich marshy bog land, but rather any loose, well-drained land, containing all the elements necessary for the proper nourishment of the tree. That it is found on the poorest kind of land in Europe is no proof that it prefers such; but merely goes to show that the olive tree is remarkably patient and long-suffering.

Personal observation in Europe and Africa has convinced me that, in California, the crops are larger, other things being equal, than in Europe; while analyses made at the University prove that as a rule the percentage of oil contained in the flesh of the fruit is greater than that shown by foreign chemists for continental olives.

CARE OF THE OLIVE TREE.

It is an error to suppose that the olive is by nature more irregular in its crops than any other fruit tree. If let alone, on the contrary, it would seem to be more regular. The apparent irregularity seems to us to be due to a neglect of the usual care in the cultivation, and not all to any inherent tendency to be irregular. The most important thing in olive culture, as in the case of that of all fruits, is the retention of the moisture in the soil, by proper plowing, cultivation, etc.

Pruning.—Of all the operations in olive culture, after the cultivation of the soil, that of pruning is the most important. The influence of the operation is incontestable; for intelligent pruning regulates the production of fruit and improves its quality. The drupes are larger, the crop is more abundant and more regular when the nutritive elements in the sap have been properly fostered and turned to the profit of the tree in fructification.

But while this is accepted by all intelligent olive-growers, there are many who, relying on tradition and abnormal conditions found elsewhere, practice most remarkable systems, in some cases most injurious to the tree. In order to understand the importance of the operation, and the principles that should guide us, let us consider what the olive tree is, and what are its leading characteristics.

"The olive belongs to the family of *Oleaceæ*, which have persistent leaves, and which bear fruit with pits; *it bears its fruit on the wood of the preceding year, and never twice on the same wood.* It throws out adventitious shoots very readily, and suckers abundantly. Finally, it can, by rational pruning, be made to yield regular, abundant, and early crops." Such is the definition of the olive tree as given by M. F. Gos, Director of the National School of Agriculture at Antibes, France. If we keep this definition always in mind we have the true guide for pruning the olive.

In the case of a young plantation the first important object is to give the tree a strong, vigorous start, to prepare it for subsequent treatments. One of the commonest practices seems to be to cut away all the lower shoots on the trunk of the tree as soon as they appear at the end of the first year. In consequence, we find that the growth is checked, the tree grows very little the following year, and gets so top-heavy as to require a stout stake to keep it from falling to the ground. The best method would seem to be to allow the young tree to grow as it will the first year, and the following spring to trim off the *ends* of all the lower shoots below the point where it is desired to have the tree "head out."

The fact that the growth of the roots is in direct ratio to the foliage, should not be lost sight of. When the tree is transplanted, the roots have been cut away to such an extent that its life is in danger; and all efforts should be directed to giving the young tree as vigorous a root growth as possible before any attention is paid to the ultimate shape of the tree. I have seen many plantations retarded for several years by too great haste in "shaping the tree." Once the young olive has a vigorous root growth, it will support the severest kind of pruning, but it will be stunted if "shaped" too soon.

At the end of the second year, all the lower shoots can be cut away without endangering the growth and development of the trunk. It should be observed that in cutting away a branch, care should be taken not to cut too close to the main stem. Though not so neat, it is better to leave a spur a half of an inch long, even at the risk of having a crop of young growth start around the spur, to be cut away at some other time. Cutting too close to the main stem is a fertile source of feeble, diseased trunks, and consequently of small crops of small fruit when the tree has reached full growth.

Having, then, a young tree at the end of the second year, with no shape at all, and a mass of shoots of various lengths all over the tree, we must decide at what height the tree should branch. Some are in favor of having olive trees branch out five or six feet from the ground, and training them afterwards like forest trees. Others prefer the low, spreading, "bush-like" form. It is claimed for the high-branching plantation that it is easier to cultivate close to the trees and that the ultimate fruit-bearing surface is vastly increased, while the danger from insect and fungous diseases is greatly lessened. It is claimed for the low-growing plantation that it is easier to harvest the crop, that it is easier

to prune the tree, and that there is less danger from sun-burn on the trunk; while the ground can be cultivated with as much ease as in the case of high pruning. However this may be, it is certainly true that there is danger of severe sun-burn in hot climates; I have seen hundreds of beautiful trees very much injured from it where the trunk was not protected.

Low-pruning renders the harvest much less expensive, and facilitates access to all parts of the tree. So far as regards diseases, it would seem that, since the introduction of the Australian ladybirds, it is better to prune low, if for no other reason than to furnish these friendly insects with a good breeding-place. Mr. Ellwood Cooper, of Santa Barbara, has after almost twenty years of experience, abandoned the high pruning for the low.

In localities subject to frost, it is best to prune the tree as high as possible, in order to escape frost-bitten fruit in case of an early frost. In California, with its very fertile soil, the olive tends to run to wood, and pruning too high would seem to cause a loss of force that might be given to the fruit instead of to the branches. One of the evils of high-growing trees is most strikingly seen in the neighborhood of Nice, where the trees are as large as oaks. Not only is harvesting very expensive, but the yield per acre is less than where the growth is kept within proper limits. It has been found that "low pruning" in the case of spreading trees, such as the apricot, peach, etc., does not give any more trouble in cultivation than the system of high pruning, and at the same time renders the harvesting much easier and cheaper. Hence, we find that the tendency now is to a far lower system of pruning than heretofore. In the case of the olive, we should not forget that, with very few exceptions, it bears most of its crop on the lower branches. Some varieties, in fact, never bear fruit on the upper branches. We therefore feel that we should be in favor of low pruning, other things being equal.

Having then decided to favor low pruning, what form should be given to the tree? The simplest, the most easy to obtain, and the easiest to maintain, is without doubt, the "goblet" form. It is well adapted to the most feeble as well as to the most vigorous varieties, and at the same time brings all parts of the tree into free communication with the air and light, besides facilitating pruning and harvesting. In our climate and soil, the olive is very vigorous, and tends, if let alone, to run to wood; hence care should be taken, from the start, to train the tree in goblet form so as to maintain it in good proportions.

The practice of trimming off at each pruning the twigs at the base of the branches, cannot be too strongly condemned. It is the branches at the base, especially those that fall toward the ground, that bear most abundantly, when given sufficient room for development, with proper amount of air and light. The heaviest crops are obtained from well-pruned trees, so even where labor is as expensive as in California it would seem to be economical to prune regularly. It must not be lost sight of that the action of light is an important factor in the formation of the oil in the fruit. Besides this process resulting from the direct action of the sun's rays, there is another equally important result on the coast of California, viz.: The check to fungous diseases, which never develop so well on well-aired and well-lighted trees.

Among fruit trees and shrubs, some (such as the grapevine) bear their fruit only on the wood of one year; while others (such as the pear,

the apple, etc.) only bear on old wood. Between these two types there is another of which the olive and the peach are the best known examples, which bear only on the wood of the second year. In this latter case a twig starts one year and is capable of producing fruit the following; but the part that has once produced fruit will never again bear. However, the shoot will grow longer, and *on the prolongation* there will be a succession of crops for a *limited number of years*, when the fruit-bearing branch will become feeble and finally die. If removed in time, it will be replaced by a new fruit-bearing twig at the base of the old one. A peach tree, pruned in this manner, has been made to produce regular crops for over a century. The most wonderful results have been obtained in the case of the peach, which is a more difficult tree to handle than the olive, for the reason that it is more difficult to make a peach tree shoot out new fruit branches to replace the old ones, than in the case of the olive. Otherwise, the mode of vegetation is exactly the same.

We should never lose sight of the principle that *the olive never blossoms on other than wood two years old*, and that it produces adventitious shoots with the greatest ease. After having applied the general principles of pruning (short pruning; suppression of foliage on the strongest side; long pruning and trimming toward the vertical on the less vigorous side in order to maintain the equilibrium and shape; after having suppressed the woody branches and suckers, and having insured free circulation of air and light throughout the center of the tree) it is not necessary to have recourse to any severe system of pruning. The pruning of the olive, then, consists in simply cutting away the feeble fruit branches that have produced fruit for several years in succession.

Time to Prune the Olive.—Immediately after the harvest is the best time to prune the olive; for then the tree sends out a new set of fruit-bearing twigs. During the following spring all suckers should be suppressed, and all vertical suckers should be cut off.

Should the Olive be Pruned Frequently?—Here we are in the presence of many systems, all of which have warm advocates. In the most progressive olive-growing regions of Europe annual pruning is practiced. This results in annual crops. Each year, after having gathered the crop *by hand* and NOT by *beating off the fruit with sticks*, all branches that have borne fruit are pinched. This causes the formation of new fruit-bearing twigs for the following year; at the same time it does not interfere with the maturing of a good crop. In spite of the high wages paid in California it would seem economical to prune annually and have regular crops instead of every two years, as in Europe, and have irregular crops.

Certain varieties, such as the Mission, have a tendency to send out a number of very long vertical branches. If these be not regularly "topped" the tree soon becomes top-heavy, besides rendering the harvesting of that part of the crop almost impossible.

FROZEN OLIVES.

There are few parts of the olive-growing regions of the world where an exceptional season or an early frost does not sometimes surprise the grower before the harvest is completed. The fruit of the olive is much more sensitive to the effects of cold than the tree itself. Hence, in localities thus subject to early frosts, care should be taken to plant only those

varieties that mature early, for once an olive has been frost-bitten, it is next to impossible to make a salable oil out of it, and it is quite impossible to make a pickle that can be eaten. The water in the juice of the olive freezes, and in so doing expands, tearing the tissues of the flesh. This in itself, of course, would not injure the quantity or quality of the oil in any way, but unless the frost-bitten drupe is at once crushed and the oil expressed, the broken tissue decomposes and imparts to the oil a most disagreeable taste and odor, rendering it unfit for the table.

Among the samples of olives received at the Station this year were several that had been frost-bitten, either before picking or while awaiting shipment. These were separately made into oil as soon as possible. It was found that a delay of three days from the time the olives were frozen to the time of crushing and pressing, was fatal. The oil was, to the eye, as clear, and to all external appearances as good, as that made from unfrozen olives, but the taste was such as to render it unfit for use. The odor was very disagreeable and very pronounced, and those who tasted the oil pronounced it "made from fermented olives."

When we consider that a delay of three days in crushing caused this, we can at once realize the importance of early harvesting, and therefore, of the selection of early maturing varieties to escape frost, for on a large scale it would practically be impossible to express the oil any sooner than three days.

This fact accentuates the importance also, of picking the fruit as soon as it reaches true maturity, instead of leaving it on the trees any longer than is absolutely necessary.

From the University Experiment Stations it was learned that the Nevadillo Blanco was the first to be frost-bitten, the Nigerina second, and the Pendulina third. This being an exceptionally severe season, it was found that at the four Stations where there were olive trees in bearing, all of the varieties were frozen before the first of January.

It would be well for oil-makers who buy the crops of local growers to look carefully to this, as I know of many having been deceived. It is far better to have the crop harvested early, evaporated, and well stored, than to let the fruit hang on the trees till the grower "has time" to pick them, risking the ruin not only of all the frozen fruit, but of all oil that is mixed with this product.

MATURITY.

This is a more important subject than is generally supposed. Indeed, the common ideas concerning the proper state at which the olive should be picked, either for pickles or for oil, are for the most part wrong, being based on false premises concerning the chemistry and physiology of the olive. It is regarded as fundamental that an olive is not ready to be harvested before it is jet-black, and that it makes no difference how long it hangs on the tree after this jet-blackness has been reached. The old European myth that the longer the olive remains on the tree after it begins to color, the more oil is formed in it, seems to be accepted even in such a progressive country as California.

The actual quantity of oil in an olive is the same the day it first reaches redness, as two months after jet-blackness has been reached, tradition to the contrary notwithstanding.

The change that takes place in the composition of the olive oil itself by

such waiting, is marked, and bad for the quality of the oil. Other things being equal, the longer an olive remains unpicked after true maturity has been reached, the greater the amount of palmitic and stearic acids formed at the expense of the olein, or that which gives the true quality to olive oil. This change in the proportion of the constituents of the oil causes it to become "greasy" to the taste, and more apt to solidify or deposit a white granular sediment in the bottles. On the European market such "greasy" oils do not command the same prices as those that have not this characteristic. The difference in price is sufficient to make it worth the while to remedy the defect by more prompt harvesting.

But aside from this loss of quality, there is considerable loss caused by the olives falling to the ground when "dead ripe," also loss from birds and the larvæ of certain flies, such as the *Dacus oleæ*, which in Europe sometimes cause the loss of the greater part of the crop.

HARVESTING.

The most common method of removing the olive crop from the trees in Europe is by means of poles. The ground underneath the tree may or may not be covered with a cloth, and the fruit is beaten off, and afterwards gathered up into any sort of receptacle. This custom cannot be too severely condemned, as well as that of using "combs" or rakes, as is done in some parts of California. The olives are so bruised that it is impossible to keep them any length of time, however short, without their moulding and becoming unfit for the manufacture of any but the most inferior grades of oil. The trees are scratched and torn to serious extent; the young and tender shoots are knocked off, and the olives get so mixed with leaves, etc., that the separation is rendered impossible, besides the irreparable injury to the fruit-bearing wood for the following crop. Where the highest grades of oil are made only hand-picking is allowed, great care being taken to avoid gathering the leaves, etc., at the same time. In California only hand-picking is commonly employed by rational oil-makers. On large plantations, such as those in Santa Barbara and elsewhere, where the trees are trained high, it is customary either to drive a wagon, on which are small step-ladders, under the tree, and thus do away with the necessity of handling large, unwieldy ladders, or to use "patent pickers"—which are nothing more than easily-moved ladders on wheels. The workmen use either buckets, baskets, or canvas bags, so attached to the body of the picker as to enable him to use both hands at once. This greatly facilitates the operation, and at the same time does not bruise the olives so much as the direct picking into a hard bucket or basket.

For pickles the greatest care is necessary. The slightest bruise in the fruit will detract from the value of the pickle, be it preserved ever so carefully. In some parts of Europe and California it is customary to pick the olives destined to be pickled into buckets half filled with water, so great importance is attached to keeping the fruit sound and free from bruises. From this it will be seen that the essential point in harvesting the olive crop, whether for pickles or for oil, is to avoid all bruises.

It is also necessary to finish the harvest as soon after it has been commenced as possible. We have shown how very important it is that the olive should be picked at proper maturity, and not be allowed to get

overripe. Practically, on a large scale, it is difficult to harvest the crop with sufficient rapidity to keep pace with the maturing of the fruit. No doubt it is true that it costs no more to hire a hundred men for one day than one man for a hundred days, but it is not always possible to do so. It is possible, however, to make due preparation in advance, and to have the work done as rapidly as possible, knowing that the quality of the oil will deteriorate much less if the fruit is picked and well stored than if allowed to hang on the tree. Besides, it is far easier to keep the olives from moulding and acquiring bad tastes when they are picked before jet-blackness has been reached.

The expense of harvesting is greatly lessened by the low pruning of the trees. Aside from obtaining a larger crop from low-pruned trees, and the reduced cost of harvesting, it is much easier to carefully handle the olives and avoid bruising when the fruit to be picked is within easy reach of the workman, and the distance between the workman on the tree and the main receptacle into which he empties his basket, etc., is small.

As soon as the olives have been picked, the workman should empty his "apron" or basket into *boxes*. The custom of putting the olives into sacks or very large bins cannot be too strongly condemned. No amount of careful sorting can ever make up for the damage thus done the crop. The boxes used to bring the crop from the orchard to the mill should, in no case, be charged with more than 75 pounds of olives. The oil-maker who permits the handling of the olives he uses for first-grade oil, in anything else than small-sized boxes, will soon lose his reputation. There are many illustrations of this in our own State. Here it would be well to call attention to the fact that the evaporation of the olives before crushing is merely to get rid of an excess of moisture that would otherwise favor the rapid moulding and fermentation of the fruit. It is a common idea among oil-makers, that the quality of the oil is, in some mysterious way, benefited by the evaporation of the olives as soon as they come from the field. The only good it does is to *prevent* moulding or fermentation, otherwise it is an expense that should be avoided, if possible, by crushing the crop at once.

If the olives are poured into sacks in the orchard and loaded on wagons, as is done in many places, and thence carried over rough roads to the railroad, re-shipped many times till they reach the mill, and then evaporated, the oil made from them will be about equal to a fourth-grade oil made in the usual way. I mention this because I know that it is being done, and I have been asked why the oil had a "peculiar earthy taste." There is but one way to avoid this, namely, by pouring the olives from one receptacle into another as seldom as possible, and then taking all precaution not to let them fall from too great a height. The custom of letting the fruit remain even for a short time in piles or masses of any considerable height cannot be too carefully avoided. An olive that has been bruised and allowed to remain in still, warm air will become mouldy within twenty-four hours. Once it is mouldy, the evil has secured a place in the fruit and whether it be evaporated or not, the mould is still there, awaiting only favorable circumstances to continue its development, either before the fruit has been crushed or after the whole has been pressed. Moulds do not develop on the *dry* surface of unbruised olives; they require a certain amount of *moisture*, usually supplied by the juice of the bruised olive, or even when it has not been

bruised, if the evaporated water cannot at once be carried off from the surface of a perfectly sound fruit, there is ample moisture supplied to start the mould germs. This is usually the case when sound olives are kept in layers of more than three inches in thickness without a current of dry air in free circulation on all sides of the fruit. The free circulation of air is essential, for even though the crop be evaporated and stored in large heaps, without free circulation, there is always sufficient moisture to cause the germs to sprout, thereby causing the fruit to mould.

Of course bruised olives are the most apt to develop fungi; in fact, it is next to impossible to prevent badly bruised fruit from moulding. The bruising of an olive means that all the cells of the injured part are killed, and that the mycelium of the fungus can have unlimited nutritive media for its development. The bruising simply kills the vitality of the cells and gives full swing to the unhindered development of fungi. When an olive is so badly moulded that the mould can be seen with the naked eye, it is in the last stage of decomposition. It must be remembered that the fungi that cause olives to "mould" are essentially microscopic, and it is only when a countless growth is present that they can be detected by the naked eye. Hence, too great care cannot be taken to prevent the slightest growth of fungi. Just so surely as there is no free circulation of air, so surely will there be mould, to a greater or less degree, even though the olives be not bruised.

STORING THE FRUIT.

It is a matter of great importance to have the oil-mill sufficiently large to crush the olives as soon as they are picked. Unfortunately, owing to the necessary expensive machinery, few can afford to have their oil-mills on a scale that will permit of this. Hence, it is necessary to store the fruit in such a way that as little deterioration as possible takes place. There are two ways practiced in California. One is the European method of storing the fresh olives in shallow trays with loose bottoms, so that the air can circulate freely. The other is to evaporate part of the water of vegetation by artificial means, and then to store in shallow trays. In hot dry climates, such as are found in the interior of the State, the San Joaquin Valley, etc., artificial heat is not necessary for the evaporation of the fruit. But along the coast, where damp fogs sometimes prevail for weeks at a time, artificial heat becomes more important. Though the use of artificial heat is not as good as the non-application of it, yet it is practically better to put up with the damage done by artificial or forced evaporation, rather than incur the risk of far greater damage resulting from the moulding of the fruit consequent to the storage of unevaporated olives in moist climates such as are found on the coast. Nothing takes away so much of the quality of olive oil as a slight mouldy taste, which can be imparted by a few decomposed olives. When an oil has once acquired this taste, *there is no way of getting rid of it.*

As soon as the olives are picked, they should be at once taken to the oil-mill and if not crushed at once, or within a couple of days, they should be dried in shallow trays similar to those used in the drying of peaches, apricots, etc. Great care should be taken to avoid over-heating, which is fatal to the quality of the oil. On no account should the temperature be allowed to pass 110° F. Even when evaporated to one third

the original weight, the olives should not be stored in layers more than three inches thick in the trays.

CLEANING THE CROP BEFORE CRUSHING.

However carefully the olives are picked, there will always be a considerable admixture of leaves, clods, and foreign substances in the crop as it comes from the orchard to the mill.. Careful oil-makers attempt to clean the fruit before crushing. Some employ children to pick out the impurities by hand, others attempt to remove the lighter impurities by winnowing, either by an ordinary fan-mill or by letting the olives fall through a current of air; others again use water. Of all these methods the water seems the best; for the winnowing, either by hand or machinery, will only remove the lighter impurities and has the disadvantage of bruising the berries. A properly arranged water-trough enables the crop to be handled far quicker, without bruising; and at the same time removes all soluble matters, and the very fine dust which adheres to the skin too strongly to be removed by the action of air. Olives grown along the roadside or in a dusty locality are sometimes so covered with dust that it is almost impossible to see the natural color. All this is removed by good washing, and the ease and rapidity with which the crop can be handled gives to the water method a great advantage. The olives, being stored in the loft above the oil-mill, are made to fall down a large pipe into a large trough with perforated bottom, so arranged that by a single movement the auger holes in the bottom may be opened or closed by a lever or slide. The water supply should be so regulated that the trough can be filled almost instantly. One end of the trough should be fitted with a slide so that after washing the berries and skimming off the leaves, the whole could be opened and allowed to run into a bucket with perforated bottom, standing over an escape pipe. In this way a great saving of time can be effected in the handling of the olives, besides the advantage of crushing only clean fruit.

It is frequently said that olives should not be wet before crushing, on account of the supposed bad effect of the water, either upon the oil or in other ways not clearly described. This is a mistake. Water alone, without heat, can do no harm whatever. In case the olives have been over-dried it is the custom in many of the best oil-mills to add enough to supply the deficiency, and thus render the crushing and expression of the oil easier. It is certainly true that hot water has invariably a bad effect on the oil. It is said by many of the experts of Europe that the quality of olive oil varies inversely as the temperature of the water used. All oil made with the application of water heated above the normal temperature of the air is rendered inferior, fit only to be used for burning or lubrication.

There is no inconsiderable saving in the quantity of oil by the moistening of the skins of the evaporated olives with water; for otherwise just so much oil would be used up in merely wetting the skins of the fruit, and no amount of force can ever render this available.

CLEANLINESS IN OLIVE OIL-MAKING.

Too great stress cannot be laid on cleanliness, the want of which may, without any exaggeration, be said to be the most fertile source of inferior oil. It is useless to have an expensive, modern oil-mill, if scrupulous

care be not taken to keep not only the machinery itself, but the building and everything near it perfectly clean. The mill-stones and crushing-trough, etc., should be well washed with hot water at least once every day, even when the mill works day and night without interruption. It is the common belief that the mill-stones need not be washed so long as the mill is kept constantly at work. This is an error; for the splashing of the juice heavily charged with vegetable matter and oil will in a short time cause it to become befouled with one of the most fertile materials for the breeding of endless fungi, which scatter their spores everywhere and impart a bad taste to what might have been, otherwise, perfect oil. The floors of the buildings soon become spattered with oil and covered with scraps of skin, flesh, etc. Constant sweeping will not serve to correct the evil; only scalding water freely applied will keep everything properly clean and sweet-smelling. The oil as soon as it is separated from the juice should be at once removed from the immediate neighborhood of the oil press, and kept carefully guarded from every odor.

Above all, smoking should not be tolerated. Not merely smoking in the neighborhood of the oil-mill itself, but the workmen should not be allowed to smoke at all, even when not on duty. *All smells, of whatever nature*, should be kept away. At the end of each season, or just before the beginning of a new campaign, the walls of the building, etc., should be given a generous coat of whitewash. Every speck of rust should be carefully banished from all possible contact with olives, juice, or oil. All smoke should be excluded; for olive oil will acquire a "smoky" taste if a wood fire be permitted anywhere near the premises.

THE OIL-MILL.

The oil exists in the olive in a finely emulsified state in the juice, which is equally distributed throughout the drupe. In order to express this oil-containing juice, it is necessary to crush the flesh in such a way as to break the tissues and allow free egress to juice and oil. Practically this operation has always been done by means of large mill-stones revolving in a trough-like path, crushing to fine paste the pit as well as the pulp of the olive. This is not the best way theoretically, but the simplest thus far practically. The kernel of the olive pit imparts a bad taste to the oil, besides introducing certain oils that cause the oil of the flesh, or the true olive oil, to become rancid much sooner than if the pit were not broken. It is not necessary to remove the pit from the mass of flesh before pressing, indeed it is better to leave the pits to stiffen the paste and thus render it more easily handled. All that should be, if possible, avoided, is the breaking of the pit and the consequent mixing of the flesh-oil with the kernel-oil. It is asserted that it is better to crush the pits in order to obtain the oil that is therein found. Reference to the tables will show the futility of so doing with any such object in view. The actual amount of oil contained in the pit is so very small, and it is so disseminated through the hard material composing the pit, that its extraction by other than purely chemical means is not possible. Hence there is nothing to be gained in this respect by crushing the pits, and great injury is done the quality of the oil. Unfortunately the machines thus far constructed for the crushing of the olives without breaking the pits are imperfect, and not as practical as could be desired.

Though many inventions exist having this object in view, they are so imperfect that we know of none that it would be safe to recommend at this moment. The nearest approach to good practical results, when working on a large scale, ever seen by the writer, was an adaptation of the old "arrastra" principle. Instead of one large mill-stone revolving in a large circle, two mill-stones revolving on a very short path are used. Instead of hitching a mule to the outer end of the beam, the crushers are made to revolve rapidly by machinery. Care must be taken not to crush too rapidly, for over a certain velocity so much heat is generated by friction that the oil is "burned"—*i. e.*, heated till it acquires a bad taste. Instead of allowing the heavy mill-stones to rest their full weight on the bottom of the crushing-trough they are made to revolve an inch or so above it. Then, by putting a sufficient quantity of olives in at a time, the flesh is well broken and lacerated by friction, one olive against the other. The height can be regulated by means of screws so that the same machine can be used for the grinding of the residues for inferior oil. The machines that accomplish this tearing of the flesh without breaking the pulp are very diverse in principle, but none have been found thus far to be equal, on a large scale, to the mill-stones revolving in the air.

Whatever be the machine used to crush the olive, it should never be made of iron. The juice of the olive is rich in vegetable acids, most important of which is tannic acid. The action of these acids on the iron is most rapid and marked. That of tannic acid on iron results in the formation of *ink*, which imparts a characteristic taste to the oil, as well as a black color, almost ruining it for consumption. These evil effects are avoided by the use of GRANITE, both for the crushing-weight and for the bottom of the crushing-trough. In case it is not possible to obtain granite in time, very little evil will result if well-tinned iron is used. As a rule, however, it is cheaper and easier to use granite, which has the advantage of being much cleanlier than tinned or untinned iron. The market is well supplied now with either granite or tinned iron oil-mill machinery.

OIL PRESSES.

Once the olives have been reduced to a mass of well-ground pulp (the pits being broken or not as the case may be), it is necessary to put this under a powerful press and separate the liquid part, composed of juice, oil, etc., from the pulp, pits, etc.

In Europe the pulp is transferred at once into large, strong, circular, grass mats holding about twenty-five pounds. These are piled one upon the other under the press, and the pressure applied slowly till the oil and watery juice cease to exude. The great advantage of the mats is that they enable the pulp to be quickly handled, and maintain the column of broken olives in the most convenient position possible, without the aid of perforated metal cylindrical sleeves, etc. The oil from this first operation is called the "first pressing." When once the mass seems to be thoroughly dry, the press is "unkeyed" and the mats emptied of their contents, which are again crushed under the mill-stones. Before refilling the mats the comparatively dry mass is moistened with water at normal temperature and made into a stiff paste for convenience in handling; the mats are then refilled and the whole is again pressed, the resulting oil being the "second pressing." In case it is so desired,

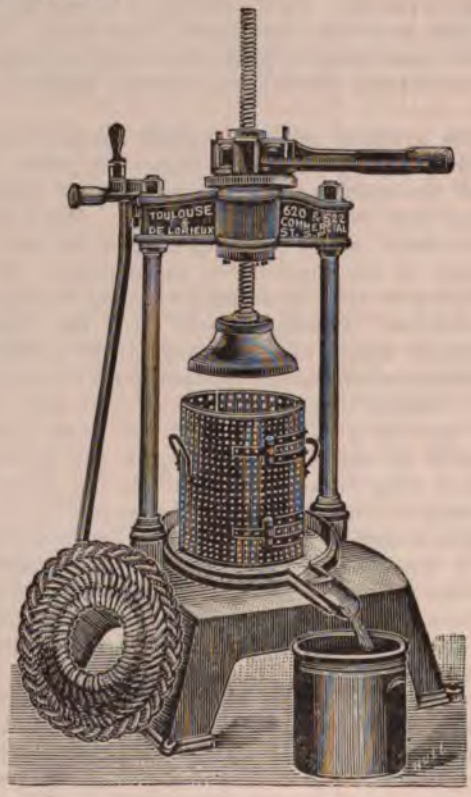
this operation is repeated once or twice again for the "third" and "fourth" "pressings." The oil from these successive pressings is inferior to the one preceding. As a rule hot water is applied to the paste to extract the "third pressing," the quality of the oil being so inferior to the two preceding pressings that it cannot be mixed with them.

While the finest oil comes from the first pressing, it is in some places the custom to mix the first and second pressings together, there being little difference in quality, *if no hot water is used*, that for ordinary use no great harm results. When oil of the highest grade is made, the pressings are kept separate. In California it is rare to find more than two pressings made, and then hot water is not used. In some cases a third pressing with hot water is made for inferior grades of oil. It is not at present considered economical in this State to make a fourth pressing.

Whatever be the grade of oil made, grass mats or strong cloth must be used to hold the pulp together while under the press. The grass mats of Europe are for the most part too expensive for general use in this State, so cloth has been substituted for them. Mats cost now from $1 to $2 each in this State, while cloth costs from 35 cents to 60 cents in sizes large enough to accomplish the same result. Several kinds of cloth have been tried in this State with varying success. Mr. Ellwood Cooper and others use "Russian crash." At the University Experiment Station several kinds of cloth were tried during the season of 1893–94. No Russian crash could be obtained in time for experiment, so linen "huck," various grades of "duck," and sail cloth were tried. The linen huck proved a failure; the "duck" was better, but not an entire success; while the sail cloth proved quite satisfactory. It is hoped that in a very short time arrangements will be completed for the manufacture in California of mats similar to those used in Europe.

Whatever be the material used to hold the pulp during the pressing, certain kinds of presses are more convenient than others. On the market to-day there are many presses that are adapted only for the use of mats, and others equally well adapted for the use of cloth or mats. The press in use at the University of California is adapted to both. We give below a cut of this press. Examination of this figure will show that the "follower" on the end of the press screw is round and unattached to the columns that support the screw. Also that this "follower" fits into a hard metallic "sleeve." This is a great convenience, in that it enables the workman to put twenty-five pounds of pulp on a piece of cloth, fold over the ends, and place the whole in the sleeve with great rapidity; at the same time there is no trouble about maintaining the column in a vertical position while enormous force is brought to bear on the whole. It should be noted, also, that the point of application of the force is fixed, which many consider a great convenience. Whatever be the kind of press used, it should be either of well-tinned steel, or should have a loose tin covering put on the bottom so as to avoid as much as possible direct contact of the olive juice with the rough iron for reasons already given. At the University Experiment Station it was found necessary to use the tin bottom-cover on this account, the press being of untinned iron. As a rule it is found that hydraulic pressure is not necessary for the first and second pressings, the force of two men on the lever being ample. It should be noted that nothing is gained by rapid pressure; on the contrary, it seems that less oil is obtained in

this way than if the same power be applied very slowly. It is customary to press gradually for a moment until the juice seems to run freely, then wait fully a minute till the flow of juice has almost ceased before again keying up the press. There will be far less juice coming from the press if the olives have been evaporated—but this is a mere matter of detail in separating the oil from the juice. The quality and quantity of oil are not affected. Though it is easier to express a small quantity it is harder to separate the oil afterwards, unless water be added to dilute the juice.



OIL PRESS used in the oil-room of the Central Station, showing European grass mats, perforated "sleeve," etc.

The press-room should be separate from that in which the olives are crushed, but on the same level; and if possible a floor above that in which the "separator" is kept. It is most economical to have the olives stored on the floor above the crushing-room. In this way there is a great saving of time in the handling, besides greater cleanliness.

THE "SEPARATOR."

One of the most troublesome processes in the making of olive oil is the separation of the oil from the watery juice and pulp after it comes from the oil press. The universal custom thus far has been to collect this mixture of water, oil, and pulp as it drips from the press and leave it

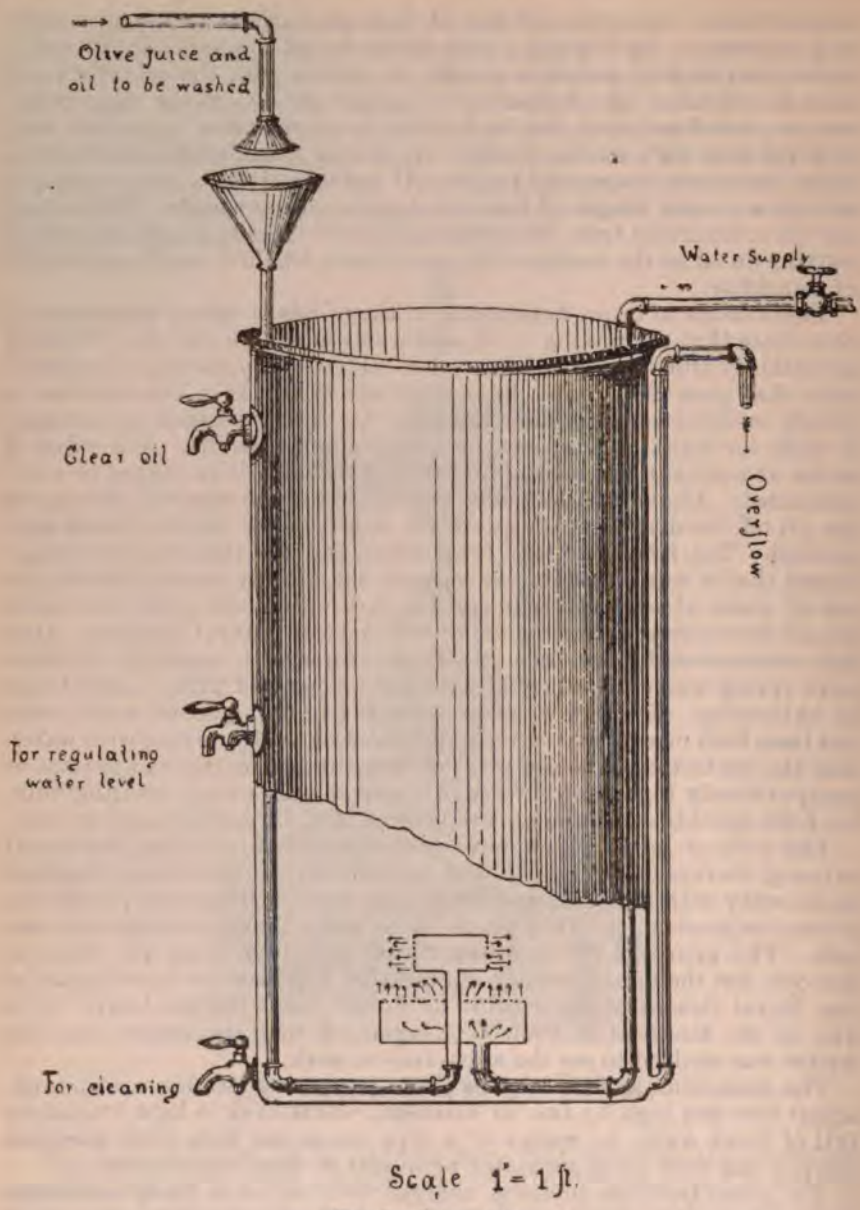
several hours; then skim off the oil from the surface as fast as it rises. The makers of the highest-priced European oil are very careful not to allow their highest grades to remain in contact with the juice for more than four hours. The makers of cheap *peasant oil*, on the other hand, are very careless about this, and have, in consequence, a product that sells for very little on the market. It makes no difference whether the olives have been evaporated or not. It is distinctively a bad practice to leave the oil any length of time on its own juice or dregs. The sooner the oil is separated from the fermentable juice the less danger there is of putting an oil on the market with a rank taste, which forms the beginning of rancidity.

There seems to be an impression on the minds of many oil-makers of this State that the mixing of oil and water is bad for the oil. While it is certainly true that it is bad to mix oil and *dirty* water, it is equally true that pure clean water in no way affects the oil. The mixture is purely *mechanical*, and, unless the water be so very alkaline as to render it unfit for drinking purposes, no possible harm results. The value of water at normal temperatures for diluting the olive juice cannot be overestimated. I have seen oil-makers in this State who were still skimming the oil off the drip from the press six months after the olives had been pressed. The fruit had been evaporated, and the juice was so concentrated that it was impossible to separate the oil any sooner without the use of water at a normal temperature, to so dilute the juice as to allow the oil free room to rise to the top by reason of its natural lightness. Had this concentrated juice been mixed at once with a quantity of fresh, pure spring water the oil could have been separated within a few hours by skimming. Even after the hot weather had begun the oil would have not been hurt in any way by immediate separation by mixing with water. But the contact of oil and a mass of fermentable matter as the juice at comparatively high temperature of summer was simply inviting ruin, for both moulds and ferments are favored in their development by heat.

The evils of long contact have been realized for a long time by all rational European oil-makers, and various devices have been imagined to do away with it. For hand-skimming, besides being bad for the oil, is very expensive, requiring much labor and expensive rooms and vessels. The principle of water-separation had been tried for years in Europe, but the most practical contrivance was seen in the oil-room of the Royal School of Agriculture at Portici, near Naples, Italy. It is due to the kindness of Prof. E. Mingioli, of that institution, that the writer was enabled to see the apparatus at work.

The apparatus, as shown in the plate, consists essentially of a tin tank, about four feet high by two in diameter. This tank is kept constantly full of fresh water, by means of a pipe connected with some adequate supply, the level being regulated by means of stop-cock outlets.

The juices from the pressing, charged with oil in a finely emulsified state, are made to flow into the tank near the bottom, through a small "drum," perforated laterally. Immediately below this oil-escape is a large flat "drum," perforated on the top, from which a stream of fresh water escapes in vertical jets. These two currents of oil and fresh water at once mix, and the oil passes upward, by reason of its lightness. Being in very small drops, it is washed of its heavier impurities (tissue, coloring matter, etc.), and reaches the top of the column of water in an almost perfectly clean state, having left all grosser impurities to be



THE OIL SEPARATOR.

carried off through an escape pipe at the bottom. When sufficient oil has been collected at the top, a stop-cock is opened and the oil runs off ready to be clarified. The level once established, the apparatus will work uninterruptedly for a long time without being cleaned out. Though the small quantities of olives at the disposal of the Station did not permit of any long-continued test of the process, yet it was found that

the larger the quantities used, the better the separator worked. No doubt it is susceptible of many small improvements, such as automatic regulators, etc.; still, on the whole, it was found to work very well indeed, and to be a vast improvement on the method of hand-skimming.

A model of this "separator," together with oil made at the Station, and olives, olive pits, etc., can now be seen in the Agricultural Building at the State University, Berkeley.

CLARIFICATION.

The oil that comes from the separator, or from the hand-skimmer, is not yet ready for use. Besides having some very fine particles of pulp suspended in it, there is a prickly taste to it as it is swallowed. These must be gotten rid of before the oil is marketable. The minute particles of vegetable tissue will soon fall to the bottom of the oil tank if the temperature of the room in which the oil is kept remains at the normal cool summer temperature. If it falls to 45° F., almost all precipitation is stopped. In Europe, where oil is not filtered "to death," as in this country, after standing a week or so it is racked off its dregs and passed through about three inches of cotton-batting, and is then ready for use as "new oil"; that is to say, oil with a slight prickly taste.

This prickly sensation in the throat is due to a minute quantity of acrid substances in the juice that remains in suspension on account of their finely divided state. Each variety of olive has a different quantity of these in its fruits, so this prickly taste will vary greatly according to locality, state of maturity, variety, etc. Time only is required to get rid of this sharp taste. It is a mistake to suppose that heat or the action of the air is necessary in this process, beyond the action of a gentle normal heat in maintaining the oil sufficiently liquid to enable the acrid substances to precipitate. It has not yet been demonstrated that there is any chemical change that takes place in the oil thus charged. In case there be chemical reactions taking place in the new oil, they must be mere oxidations, and the quantity of free oxygen in the oil is ample to bring about the destruction of these substances, if it is granted that this be true. The weight of evidence, however, seems to be that no chemical reaction takes place in the process of getting rid of this taste, but that it is purely a mechanical one.

Hence, the practice of the so-called "maturing" of olive oil by exposure to heat and air is bad. For while there is no necessity of either heat or air in getting rid of the prickly taste, if the oil be thus exposed for any length of time, the oil itself will oxidize; that is, it will become rancid. Thus, we see that we have everything to lose and absolutely nothing to gain by the exposure of oil to air and heat while undergoing this supposed process of "maturing." Those who practice this got their ideas of it from the peasants of Europe, who certainly do practice this pernicious custom. But, to quote the words of Napoleone Passerini, of Florence, Italy, "The peasants prefer an oil with a rancid taste to one without it." The presence of a large number of this class in California accounts for the spreading of these ideas among those who do not know peasant traits. It is certainly true that oil thus "matured" brings a far lower price on the market than oils not so treated. It is the practice of those who get the highest prices for their oils to keep them, as much as possible, from the air and heat; also, to filter them as little as they can.

Never is a very high-priced oil filtered, least of all with charcoal. The use of charcoal is necessitated by the presence of some specially rank taste that must be gotten rid of. Too much attention should not be paid to the opinions of ignorant peasants, who are accustomed to making and tasting only the most inferior oils (and wines) of the countries from which they come.

The American market requires that olive oil should be put in glass, and be perfectly clear and brilliant. This necessitates careful filtration. Strictly speaking, olive oil should not be filtered at all, for by the process of filtration it loses a great deal of its characteristic taste and odor. Highly clarified oil is prettier to look at, but is not as agreeable to the taste as that which has been allowed to deposit naturally its solid matter. The oftener an oil is filtered, the more neutral in taste it becomes. In Europe, oil is seldom clarified so highly as in America. There, simple cotton-batting is used for oil intended for domestic purposes, but in California, where only the most brilliant oil is in demand, something less porous than cotton-batting is required.

In the oil-room of the Station, experiments were made with cotton-batting, "glass wool," asbestos, and filter-paper. All but good filter-paper, such as is used in chemical laboratories, was found to be unfit for purposes of clarification. Even with good filter-paper, some varieties of oil were found to require two filtrations before becoming perfectly clear and brilliant. It was also noted that where oil was at once filtered after separation, there was a tendency to become cloudy after a month or so in the bottle. Hence, in the clarification of oil, care should be taken to use only paper of such good quality as will necessitate but one filtration.

It was found that it was impossible to filter olive oil in a room where the temperature was below 45°. Of course no heat should be used, but the temperature should be at least 50° F.

It is to be hoped that those who are fond of the true olive flavor and aroma in pure olive oil will encourage the mill-owners in this State to treat their oil as a good wine merchant treats his best wine; that is, to maintain it at an even normal temperature and rack off its dregs as long as there are dregs deposited. Treated in this way, oil will become almost as clear and brilliant as filtered oil, and will not be a neutral-tasting, greasy liquid, differing little from cotton-seed or any other oil now so extensively used to adulterate olive oil. It is far easier to adulterate a perfectly neutral oil than one with a characteristic taste. Many oil-makers assure me that they will be only too glad to put on the market unfiltered oil, provided there is a demand for it. Once the taste for unfiltered oil has been acquired, no neutral-tasting, "greasy" oil can be tolerated.

ANALYSES OF OLIVES AND OLIVE OIL.

The twenty-four analyses made in the laboratory of the Central Station during the two previous seasons have been placed in the table below with those of the season of 1893–4, thus giving more extended data for comparison of the value of varieties, and their relative adaptation in the various parts of the State.

It will be noted that the tables do not contain the iodine absorptions as in previous years; also, that a column showing the number of olives necessary to make 100 grams has been added. The reason for this

insertion is that the reader may be enabled to form a pretty accurate idea of the relative size of the fruit without troublesome cross references. This tabulation, taken with Column 1, which shows the proportion of pits and flesh found in the fresh fruit, enables the reader to determine at a glance the value of any variety for pickling. Take, for example, Polymorpha and Redding Picholine; in one case it takes 13 olives to make 100 grams, in the other it takes an average of 79 olives. Moreover, in the 13 Polymorphas there is 17 per cent of pit and 83 of flesh, while in the 79 Redding Picholines there is an average of 24.41 per cent of pit and 75.58 of flesh. Keeping in mind that for pickles the object is to have an olive that, while being as large as possible, has the smallest possible pit, one has little trouble in judging of the relative merit of whatever varieties he may have in mind.

Column 2 shows the percentage of oil it is possible to extract from the whole fruit by the most careful chemical processes. It shows also the uselessness of taking into consideration the oil contained in the pits. Even were this pit-oil available and unobjectionable, the actual quantity would not pay for the trouble of extraction; but such very small quantities disseminated throughout a mass of hard material, renders their expression by mechanical means a problem of no practical interest.

But aside from the uselessness of attempting to extract the pit-oil, the kernel imparts a disagreeable taste to the oil of the flesh with which it comes in contact, and impairs its keeping qualities.

It is Column 3 that serves chiefly for the study of the values of olive varieties. In the second row of Column 1 we find the percentage of flesh in the whole fruit; in the second half of Column 3 we find what part of this flesh is oil, and what part refuse matter.

Table II is a comparative table of averages of those varieties of which two or more samples were received at the Station. It is to be regretted that the tables are so incomplete; but it was too late in the season to make proper arrangements to obtain more samples when the work was assigned to the new assistant.

It is hoped that next year olive-growers from all parts of the State will send samples of the varieties they may have to the Agricultural Experiment Station in Berkeley, in order that this study may be made as complete as possible. It is only with the coöperation of the olive-growers that the problem of adaptation of varieties to soil and climate can be solved.

TABLE I. PARTIAL ANALYSES OF SOME SAMPLES OF CALIFORNIA OLIVES AND OILS. (CROPS OF 1890-94.)

Number	Variety.	Locality.	Date of Picking.	No. of Olives in 100 Grams.	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit Possibly Yielded by		3 Percentage of Oil Contained in Fresh	
					Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.
1	Manzanillo	Fresno	Nov. 4, 1890		13.00	87.00	.53	19.23	4.10	22.01
2	Manzanillo	Berkeley	Jan. 20, 1891		16.00	84.00	.51	21.38	3.20	25.45
27	Manzanillo	Pomona	Nov. 13, 1890	16	22.50	77.50	.66	15.10	3.00	20.00
40	Manzanillo	Mission San José	Dec. 5, 1893	32	17.00	83.00		20.84		25.10
86	Manzanillo	Pomona	Dec. 26, 1893	15	12.00	88.00	.50	19.60	4.23	22.30
	Average			21	16.10	83.90	.55	19.23	3.84	22.57
6	Nevadillo Blanco	Fresno	Nov. 4, 1890		17.50	82.50	1.60	18.02	6.60	22.00
7	Nevadillo Blanco	Mission San José	Jan. 7, 1891		24.00	76.00	1.06	23.94	4.40	31.50
8	Nevadillo Blanco	Berkeley	Jan. 7, 1891		25.00	75.00	1.05	22.72	4.20	30.30
17	Nevadillo Blanco	Mission San José	Dec. 16, 1891		20.50	79.50	.94	25.65	4.70	32.06
33	Nevadillo Blanco	Pomona	Nov. 22, 1893	28	15.00	85.00		19.30		22.72
39	Nevadillo Blanco	Mission San José	Dec. 5, 1893	70	25.00	75.00		15.35		20.50
58	Nevadillo Blanco	Biggs	Dec. 11, 1893	30	18.00	82.00		16.22		19.00
64	Nevadillo Blanco	Chico	Dec. 21, 1893	19	18.00	82.00		18.98		23.15
82	Nevadillo Blanco	Pomona	Dec. 26, 1893	29	17.00	83.00	.75	18.50	4.44	22.30
	Average			35	20.55	80.00	1.08	19.85	4.86	24.83
12	Mission	Mission San José	Jan. 8, 1891		23.50	76.50	.94	19.07	4.00	24.90
23	Mission	Newcastle	Mar. 9, 1891		20.00	80.00	.61	16.55	3.07	20.68
24	Mission	Mission San José	Dec. 16, 1891		16.50	83.50	.40	18.72	2.40	21.40
25	Mission	Fresno	Jan. 12, 1892		18.00	82.00	.70	23.08	3.70	28.15
26	Mission	Newcastle	Jan. 14, 1892		17.50	82.50	.50	17.50	3.20	21.31
42	Mission	Mission San José	Dec. 5, 1893	47	25.00	75.00		16.45		21.90
43	Mission	Mission San José	Dec. 5, 1893	42	26.00	74.00		15.31		20.00
53	Mission	Biggs	Dec. 11, 1893	26	17.00	83.00		17.78		21.40
62	Mission	Livermore	Dec. 15, 1893	34	25.00	75.00		22.73		30.29
63	Mission	Chico	Dec. 21, 1893	17	15.00	85.00		20.75		24.40
71	Mission	El Quito	Dec. 22, 1893	34	22.00	78.00		15.01		19.20
79	Mission	Pomona	Dec. 26, 1893	20	15.00	85.00	.52	19.46	3.50	22.90
87	Mission	St. Helena	Dec. 28, 1893	22	15.00	85.00		18.70		22.00
	Average			30.25	19.60	80.00	.61	18.77	3.44	22.94

13	Rubra	Fresno.	Feb. 5, 1891		19.50	80.50	.80	17.69	4.10	21.97
14	Rubra	Fresno	Jan. 12, 1892		15.00	85.00	.80	20.00	5.20	23.53
15	Rubra	Newcastle	Jan. 14, 1892		21.00	79.00	.80	27.57	4.00	34.90
32	Rubra	Pomona	Nov. 19, 1893	35	18.00	82.00		17.88		21.57
35	Rubra	Niles	Dec. 7, 1893	38	20.00	80.00		11.88		14.85
46	Rubra	Biggs	Dec. 11, 1893	42	17.00	83.00		15.24		18.40
72	Rubra (?)	Biggs	Dec. 23, 1893	42	18.00	82.00		18.40		22.40
73	Rubra	Biggs	Dec. 23, 1893	47	16.00	84.00		14.85		17.70
83	Rubra	Pomona	Dec. 26, 1893	41	16.00	84.00	.91	21.44	5.70	25.53
	Average			40.83	17.80	79.94	.82	18.33	4.75	22.28
5	Atroviolacea	Fresno	Nov. 4, 1890		23.70	76.30	1.19	13.78	5.00	18.10
16	Atroviolacea	Newcastle	Jan. 14, 1892		16.00	84.00	.73	21.90	4.40	26.70
37	Atroviolacea	Mission San José	Dec. 5, 1893	48	25.00	75.00		20.83		27.80
55	Atroviolacea	Biggs	Dec. 11, 1893	41	20.00	80.00		13.74		17.17
75	Atroviolacea	Biggs	Dec. 23, 1893	48	25.00	75.00		14.69		19.58
	Average			45	21.94	78.00	.96	16.98	4.70	21.87
11	Redding Picholine	Mission San José	Jan. 8, 1891		29.00	71.00	1.88	21.87	6.50	30.80
18	Redding Picholine	Mission San José	Dec. 16, 1891		24.50	75.50	1.17	22.99	4.70	30.70
34	Redding Picholine	Auburn	Nov. 27, 1893	78	21.00	79.00		17.08		21.60
52	Redding Picholine	Biggs	Dec. 11, 1893	91	25.00	75.00		13.27		17.70
60	Redding Picholine	Livermore	Dec. 15, 1893	67	23.00	77.00		20.80		27.00
65	Redding Picholine	Chico	Dec. 21, 1893	80	24.00	76.00		15.25		20.10
	Average			79	24.41	75.58	1.52	18.64	5.60	24.65
20	Oblonga	Fresno	Jan. 12, 1892		18.00	82.00	.90	14.95	4.60	18.23
41	Oblonga	Mission San José	Dec. 5, 1893	40	25.00	75.00		15.10		20.10
47	Oblonga	Biggs	Dec. 11, 1893	25	15.00	85.00		10.85		12.80
61	Oblonga	Livermore	Dec. 15, 1893	37	21.00	79.00		20.50		26.00
92	Oblonga	Berkeley	Jan. 4, 1894	67	20.00	80.00		9.29		11.61
76	Oblonga	Biggs	Dec. 23, 1893	34	17.00	83.00		11.10		13.40
	Average			40.60	19.00	80.66	.90	13.63	4.60	17.02
22	Columbella	Fresno	Jan. 12, 1892		17.00	83.00	.50	15.20	3.10	18.35
45	Columbella	Mission San José	Dec. 15, 1893	49	25.00	75.00		16.32		21.80
56	Columbella	Biggs	Dec. 11, 1893	28	15.00	85.00	.63	13.53	4.20	16.00
80	Columbella	Pomona	Dec. 26, 1893	19	15.00	85.00	.68	17.39	4.62	20.05
91	Columbella	Berkeley	Jan. 4, 1894	70	20.00	80.00		14.13		17.65
	Average			41.50	18.40	81.60	.60	15.31	3.93	18.77
3	Pendulina	Fresno	Nov. 4, 1890		14.80	85.20	1.04	17.40	7.00	20.50
84	Pendulina	Pomona	Dec. 26, 1893	29	13.00	87.00	.92	18.81	7.10	21.70
77	Pendulina (?)	Biggs	Dec. 23, 1893	13	15.00	85.00		10.00		11.70
	Average			21	14.26	85.66	.98	15.40	7.05	21.30

PARTIAL ANALYSES OF SOME SAMPLES OF CALIFORNIA OLIVES AND OILS. (CROPS OF 1890-94.)—Continued.

Number.	Variety.	Locality.	Date of Picking.	No. of Olives in 100 grams.	1 Proportion of Pits and Flesh in Fruits.		2 Percentage of Oil in Whole Fruit possibly yielded by		3 Percentage of Oil contained in Fresh	
					Pits.	Flesh.	Pits.	Flesh.	Pits.	Flesh.
21	Præcox	Fresno	Jan. 12, 1892		17.00	83.00	.60	12.87	3.09	15.40
54	Præcox	Biggs	Dec. 11, 1893	48	19.00	81.00	1.10	16.86	6.06	20.00
93	Præcox	Berkeley	Jan. 4, 1894	71	20.00	80.00	.72	10.67	3.60	13.35
	Average			59.50	18.00	81.00	.80	13.48	4.50	16.51
57	Uvaria	Biggs	Dec. 11, 1893	39	25.00	75.00		11.00		14.66
74	Uvaria	Biggs	Dec. 23, 1893	44	27.00	73.00		9.64		13.20
81	Uvaria	Pomona	Dec. 26, 1893	33	22.00	78.00	1.05	11.38	4.76	17.40
	Average			38.30	24.66	75.36		11.38		15.08
19	Atrorubens	Fresno	Jan. 12, 1892		18.50	81.50	.80	21.26	4.20	26.10
49	Atrorubens	Biggs	Dec. 11, 1893	28	15.00	85.00	.71	16.68	4.11	19.60
	Average				16.75	83.25	.75	18.97	4.15	22.85
50	Nigerina	Biggs	Dec. 11, 1893	36	15.00	85.00	.94	18.16	6.24	21.31
85	Nigerina	Pomona	Dec. 26, 1893	23	15.00	85.00	.53	22.35	3.46	26.30
	Average			29	15.00	85.00	.73	20.25	4.85	23.85
59	Columbaro	Biggs	Dec. 14, 1893	23	15.00	85.00	.50	17.73	3.38	20.85
78	Polymorpha	Biggs	Dec. 23, 1893	13	17.00	83.00	.66	13.65	3.90	16.40
88	Lucques	Livermore	Dec. 28, 1893	67	30.00	70.00	1.00	13.06	3.32	18.70
89	Piangente	Berkeley	Jan. 4, 1894	76	22.00	78.00	.86	13.48	3.92	17.30
90	Hervaza	Berkeley	Jan. 4, 1894	21	17.00	83.00	.37	12.98	2.20	15.60
36	Rock's No. 57	Niles	Dec. 7, 1893	65	21.00	79.00		7.12		9.30
9	Seedling, No. 10	Berkeley	Jan. 4, 1894	77	25.00	75.00		13.90		18.53
48	Amellau	Biggs	Dec. 11, 1893	19	16.00	84.00	.48	14.00	3.02	17.50

38	No. 16, Row E	Mission San José	Dec. 8, 1893	79	32.00	68.00		19.00		28.00
67	Razzo	El Quito	Dec. 22, 1893	52	20.00	70.00	1.08	23.59	3.65	33.70
70	Grossajo	El Quito	Dec. 22, 1893	53	28.00	72.00	1.03	25.03	3.72	34.76
68	Correggiolo	El Quito	Dec. 22, 1893	53	33.00	70.00	1.20	20.29	4.07	28.98
66	Frantojo	El Quito	Dec. 22, 1893	74	30.00	70.00	1.00	18.69	3.36	26.70
69	Morajolo	El Quito	Dec. 22, 1893	55	33.00	67.00	1.45	21.93	4.43	32.72
44	Regalis	Mission San José	Dec. 5, 1893	34	22.00	78.00	1.19	16.85	5.47	21.60
51	Becca Rufa	Biggs	Dec. 11, 1893	58	19.00	81.00	1.10	21.05	6.00	25.29

TABLE II. AVERAGES BY OLIVE VARIETIES, WITH MAXIMUM AND MINIMUM.

Variety.	Number of Samples Examined	Percentage of Oil in Fresh Fruit.				Number of Olives in 100 grams.			Percentage of Flesh in Whole Fruit.			Percentage of Pit in Whole Fruit.		
		Maximum	Minimum	Average	Variation	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Rubra	9	34.70	14.85	22.28	20.05	47	35	40	85	79	79	21	15	19.60
Nevadillo Blanco	9	32.06	19.00	24.83	13.06	70	19	35	85	75	80	25	15	20.00
Mission	13	30.29	19.20	22.94	11.09	47	17	30	85	74	80	26	15	19.00
Redding Picholine	6	30.80	17.70	24.00	13.10	91	67	79	79	71	75	29	21	24.00
Atrorubens	2	26.10	19.60	22.85	6.50	28	28	28	85	81	83	18	15	16.00
Oblonga	5	26.00	11.61	17.02	14.21	67	25	40	85	75	80	25	15	19.00
Nigerina	2	26.30	21.31	23.85	5.00	36	23	29	85	85	85	15	15	15.00
Manzanillo	5	25.45	20.00	22.30	5.10	32	15	21	88	77	83	22	12	16.00
Pendulina	3	21.50	11.70	21.30	10.00	29	13	21	87	85	85	15	13	14.00
Præcox	3	20.80	13.35	16.51	7.45	71	48	59	83	80	81	20	17	18.00
Uvaria	3	17.40	13.20	15.08	4.20	44	33	38	78	73	75	27	22	24.00

Examination of Table I brings out the importance of a close study of soil, climate, and varieties before undertaking to plant an olive orchard. It will be seen that there are varieties that yield a very high percentage of oil, and others that do not. Further, it appears that the same variety, on different soils, etc., may vary as much as 20 per cent in the amount of oil yielded, while the crop on each may, to all appearances, be equally heavy. Thus the Rubra, in one place, contains as much as 34.90 per cent of oil, and in another locality has but 14.85 per cent—a difference sufficient to ruin an olive-grower in a few years. This variation in oil yield is most easily studied in Table II, in which the maximum, minimum, and averages have been conveniently arranged.

It will be noticed (Table II) that in the eleven varieties of which more than two samples were received, the difference between the maximum and minimum of oil in fresh fruit varies very greatly: thus, while in the Rubra the difference is 20.05, in the Uvaria it is only 4.20—thus showing for the latter a greater uniformity in oil percentages for the State at large. The following list comprises the commonest varieties now growing in California, and the table is arranged in the order of highest to lowest variations between maximum and minimum oil percentage:

Variety.	Variation in Oil.
Rubra	20.05
Oblonga	14.21
Redding Picholine	13.10
Nevadillo Blanco	13.06
Mission	11.09
Pendulina	10.00
Præcox	7.45
Atrorubens	6.50
Manzanillo	5.10
Nigerina	5.00
Uvaria	4.20

The table shows what a matter of "guess work" the selection of varieties for orchards in the State has been thus far, and emphasizes the importance of the work undertaken by the Agricultural Experiment Station in bringing out all of these various characteristics.

It would not be safe to pass judgment too hastily, taking into consideration the relatively small number of analyses at our command, yet it will at once be seen that there are varieties that seem to be better adapted for general planting than others. Take, for example, the Mission. This is the oldest variety cultivated in California, and we have examined thirteen samples; yet it stands as a very good oil variety, never falling below 19.20 per cent of oil, and an average of 30 olives in 100 grams (144 in one pound). This fact, taken with the experiments in the oil-room, show it to be one of the preëminently safe varieties to plant. It gives an oil of very good quality, and one that keeps its marketable qualities in an exceptionally good manner.

What is said of the Mission can be said of the Manzanillo, which, while being a trifle larger than the Mission, is a more regular bearer, and ully as hardy.

The Nevadillo Blanco, while a smaller olive than either of the other two, is, by reason of its high average in oil, and its regularity as a bearer, one of the olives of the future.

The Redding Picholine shows itself unworthy of the place it has in the olive plantations of the State. Though it is a good bearer and a vigorous grower, it is the smallest olive of any of the varieties thus far found in California. It has more pit and less flesh than any other variety. Next to the Rubra it varies more than any other in the above table, and the oil-room experiments show it to give an inferior product. Of all the oils made this year in the Station oil-room, that of the Redding Picholine was the "greasiest" and the first to solidify, assuming the appearance of partly melted, yellowish lard.

The Uvaria was a disappointment, the general impression being that it was a very good oil variety, so far as regards quantity.

The Rubra, in spite of its uncertainty as to richness in oil, is a good variety when well adapted to its surroundings. The Rubra oil made at the Station was of a very high degree of excellence, and stood cold weather very well.

For the first time we have analyses of the leading Italian varieties, *i. e.*, Grossajo, Razzo, Frantojo, Correggiolo, and Morajolo. From the very high yield of oil, when we take into account that the Mission on the same soil gives but 19.20 per cent of oil, we are led to conclude that these new varieties will be of great importance in the future.

Further comment is not deemed wise at this time, owing to the fact that there are too few varieties of which samples were received from more than one locality. In another year, with the coöperation of the olive-growers of the State, it will be possible to discuss more fully the results. They are given to the public as they stand, as the only data existing at this moment.

The thanks of the Department are extended to Messrs. Alfred Wright and J. S. Calkins of Pomona, J. Rock of Niles, Hatch & Rock of Biggs, and Louis Mel of Livermore, for their generous donations of samples of olives in lots large enough to be made up into oil.

DRIED OLIVES.

While pickling the olive is by far the most common of all methods of its preparation, we frequently find dried olives used on the tables of those who duly appreciate the healthful and nourishing qualities of this fruit. Quite recently in California, this method of preparation has suggested itself to many who did not care for olives prepared in the commoner ways. Perhaps one reason that the majority of consumers did not appreciate the dried as much as they did the pickled olive, is because an unfortunate selection of varieties was made for drying. In Europe, where the use of dried olives is quite common, it has been found that but few of the many cultivated varieties lend themselves to this method of preparation, because of the natural and excessive bitterness of the majority of the varieties. Even in Europe, olives thus prepared. are seldom used as an article of food, as is the case with the pickled fruit Dried olives are there, as a rule, used as a relish, very much as the large green pickled olive is with us. The Europeans generally eat dried olives with salt; but even then, they use them as a relish and not as an article of food.

The preparation of olives in this way is very simple indeed. The berry is allowed to hang on the tree till it is jet-black, and if there is no danger of losing the crop from winds, birds, and frost, they are

allowed to become somewhat shriveled before gathering. They are then sun-dried and stored in a dry place. Artificial heat is never used, though there can be no objection to it, if used in moderation.

It is hoped that during the coming season sufficient quantities of all the varieties grown in California will be donated to the University in order to enable the Experiment Station to make thorough tests as to those varieties best adapted for this purpose.

Thus far the variety that seems to be best adapted for drying is the Atroviolacea.

THE ASH OF GRAPES.

By F. T. Bioletti.

The subject of the ash analysis of various California fruits, and its relation to soil exhaustion and fertilization, has been treated of in former bulletins of this Station. The composition of the ash of California grapes and the drain of the grape crop upon the soil, however, has not been investigated. The analyses of which the results are detailed in this paper are an attempt to throw some light upon this matter, and by means of comparison with European analyses and the analyses of other fruits, to gain some knowledge as to the amount of soil ingredients taken from the soil by a crop of grapes or wine, and the liability to the need of fertilizers, either now or in the future.

The ashes of five samples of grapes and one of wine were analyzed, with the results which are tabulated below. The samples investigated were the following:

No. 1. *Thompson's Seedless*, grown at the Agricultural Experiment Station near Tulare; a good mature sample of the variety; received at Berkeley on September 25, 1893.

No. 2. *Gros Colman*, grown at the Agricultural Experiment Station near Paso Robles; grapes very varied in size and hardly mature; received October 13, 1893.

No. 3. *Muscat of Alexandria*, grown at the Tulare Agricultural Experiment Station near Tulare; a fair, average sample; received October 16, 1893.

No. 4. *Muscat raisins*, grown by J. T. Alpeter, on the vineyard of R. H. Loughridge, at Woodland, Yolo County; sample of medium-sized, well-cured fruit.

No. 5. *Seedless Sultana raisins*, received from the same place; small, but well cured.

No. 6. *Mataro* (*wine*), made at the Agricultural Experiment Station Cellar, Berkeley, from grapes received from San José, Santa Clara County; a fair average sample of dry, red wine; analyzed when two years old.

The following table is compiled from data kindly furnished by Mr. G. E. Colby, by whom the determinations were made:

Composition of the Grapes.

Sample.	Whole Grape.		Must.		
	Water—Per cent.	Organic Matter and Ash—Per cent.	Solid Contents by Spindle—Per cent.	Sugar by Copper Test—Per cent.	Acid as Tartaric—Per cent.
1. Thompson's Seedless	81.71	18.29	25.05	24.12	0.31
2. Gros Colman	80.77	19.33	15.20	15.11	0.33
3. Muscat of Alexandria	77.88	22.12	24.80	24.43	0.48

The first two columns are the result of weighing a known quantity of fresh grapes after they had been subjected to a temperature of 100° C. for two weeks in a drying oven.

The results of my investigation of the samples described above are given in the following tables. The ashes were obtained by the method of successive leachings, and analyzed according to the ordinary method of ash-analysis:

Ash and Nitrogen Contents.

Sample.	Locality.	Fresh Fruit.		Dried for two weeks.	
		Pure Ash—Per cent.	Nitrogen—Per cent.	Pure Ash—Per cent.	Nitrogen—Per cent.
1. Thompson's Seedless	Tulare	.513	.174	3.027	.95
2. Gros Colman	Paso Robles	.452	.231	2.349	1.20
3. Muscat of Alexandria	Tulare	.658	.199	2.968	.90
4. Muscat Raisins	Woodland	.402	----------	1.451	----------
5. Sultana Raisins	Woodland	.474	----------	1.709	----------
Mean	----------	.500	.201	2.301	1.02

In the case of Nos. 4 and 5, the actual weight of fresh fruit corresponding to the quantity of dried fruit taken was not known, but was calculated in accordance with the average percentage of raisins obtained from fresh grapes.

The following averages of eight analyses of European grapes made by Blankenhorn are given for comparison:

Dry substance	14.60 per cent.
Ash in dry substance	3.65 per cent.
Ash in fresh substance	.53 per cent.
Nitrogen in dry substance	1.28 per cent.
Nitrogen in fresh substance	.19 per cent.

The nitrogen is thus about the same in the fresh fruit in both sets of analyses, the European and the California; the per cent of dry substance, however, is 36 per cent higher in the California than in the European, which accounts for the lower per cent of nitrogen shown in the dry substance. This great difference in the dry substance is doubtless due to a higher percentage of sugar in the California grapes, for the amount of ash is about the same in either case.

The following table gives the percentage composition of the several ashes analyzed, together with the average of three analyses of German grapes given by Dr. Emil Wolff. Johnson in his "How Crops Grow," gives 0.88 per cent as the average amount of ash in grapes. I can find no single analysis showing more than 0.84 per cent, while König gives the maximum of twelve analyses as 0.70 per cent, and the average as 0.50 per cent. This agrees very closely with what I have found in California grapes:

Analyses of Grape Ash.

Sample.	Pure Ash—Per cent.	Potash—Per cent.	Soda—Per cent.	Lime—Per cent.	Magnesia—Per cent.	Peroxid of Iron—Per cent.	Brown Oxid of Manganese—Per cent.	Phosphoric Acid—Per cent.	Sulphuric Acid—Per cent.	Silica—Per cent.	Chlorine—Per cent.	Total	Less Oxygen Due to Chlorine	Total
1. Thompson's Seedless	.513	53.87	8.66	6.33	2.36	*2.73	.16	15.64	2.92	4.63	3.38	100.68	.87	99.81
2. Gros Colman	.452	43.11	2.26	6.03	2.80	2.08	.26	27.18	7.01	7.45	2.40	100.58	.51	100.07
3. Muscat	.658	52.45	8.34	3.64	2.73	1.15	.28	26.57	2.37	2.23	.36	100.06	.06	100.00
4. Muscat	.402	58.99	4.42	4.43	3.88	3.04	.86	14.67	5.03	3.85	1.06	100.23	.23	100.00
5. Sultana	.475	46.33	7.94	4.35	3.44	2.63	.26	22.15	4.06	8.40	.55	100.21	.12	100.09
Mean	.500	50.95	6.32	4.96	3.04	2.73	.36	21.24	4.28	5.31	1.54	.....	.....	.....
Average of 3 German analyses	.500	50.13	1.75	11.89	3.33	.68	.....	21.09	5.62	2.01	2.17	.....	.....	.....

Analysis of Wine Ash.

Mataro	.244	43.37	7.55	8.18	5.54	1.23	.21	19.00	11.26	1.90	1.86	100.10	.08	100.02

*This determination was not made, but the average interpolated.

Taking the averages of the five California and of the three German analyses, the following table will show the amount of various soil ingredients abstracted from the soil by a crop of five tons of grapes, and comparison with what is abstracted by a crop of 4,800 pounds of wheat hay and of 20 bushels of grain:

Ingredients Abstracted from the Soil.

	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
Five tons of grapes per acre—Average of five California analyses	50.00	25.48	10.62	12.60
Five tons of grapes per acre—Average of three German analyses	50.00	25.07	10.50	17.00
Wheat hay (Johnson)—4,800 pounds per acre	246.00	43.92	19.80	42.00
Wheat (Johnson)—20 bushels per acre	24.00	7.85	11.90	24.00
Wine (Mataro, from Santa Clara Co.)—800 gallons per acre	15.37	6.67	2.39	.64

Thus it is seen that an ordinary crop of grapes is much less exhausting to the soil than a crop of wheat hay; and even if we should obtain a crop of ten tons to the acre the amount of essential soil ingredients abstracted would still be less than with wheat hay, except in the case of potash, an ingredient which is always abundant in soils where such crops are possible. If the grapes are made into wine and the pomace returned to the vineyard the crop is still less exhausting. In this regard, however, the table is somewhat misleading, for it fails to take account of the considerable amount of potash and other salts which are thrown down by the wine in aging (lees and argol), and are seldom returned to the soil. The most striking point of dissimilarity between the California analyses and the German is the high percentage of soda and the low percentage of lime in the former as compared with the latter. This is easily accounted for by the difference of soil, all the California grapes, with one exception, having been grown in the rich interior valleys, where the soils are so abundantly supplied with potash and soda that the vines take up these substances instead of lime. The exception, No. 2, was grown in the Coast Range, on a soil which, in all probability, approaches more nearly in character that on which the German grapes were grown, and here the dissimilarity between the European and the California analyses is much less marked.

The percentage of phosphoric acid agrees almost exactly with that obtained by the German analysts, if we only compare the means. The variations between the different grapes in the matter of this ingredient are, however, very remarkable. The proportion ranges from 14.7 per cent in the case of the Muscat from Woodland to 27.2 per cent in the case of the Gros Colman from Paso Robles. What the cause of this variation is, the number of analyses is insufficient to show. Apparently it depends neither on variety of grape nor locality of production; the Muscat from Tulare and the Sultana from Woodland are well supplied with phosphoric acid, while the Muscat from Woodland and the Thompson's Seedless (a close relative of the Sultana) from Tulare are in comparison but illy supplied with this substance. The difference between maximum and minimum is about as 100 to 52. European

analyses show even greater divergences. An analysis of Riesling by A. Hilger shows 27 per cent of phosphoric acid, while one of Silvaner by J. Moritz shows only 10.5 per cent—a difference of 100 to 39.

Though Maumené seems to have proved to his own satisfaction that the application of fertilizers (with the possible exception of potash) to soils devoted to grape culture is quite unnecessary, experience seems to have proved otherwise. The manuring of vineyards is a recognized and almost universal practice in Europe. Many of the most renowned European vineyards are fertilized with the manure from cattle farms, which are maintained principally for that purpose. In our own vineyards doubtless the same mode of renovating the soil would be the most beneficial, though it will probably be long, except in the oldest vineyards, before extensive or heavy fertilizing will be necessary, especially where all the pomace and the ashes of the canes are carefully returned to the soil.* In the rich valley soils the case is different. Here there is an abundance of potash, even for the larger crops obtained, but the phosphoric acid is generally scanty, and the drain on this ingredient proportionately great. Here therefore the first need will doubtless be a phosphatic manure.

The belief which has existed that the application of manure to vineyards was liable to communicate bad odors to the wine is erroneous, unless the manure should be applied so late that the grapes could come into contact with it. Provided that the manuring is done before plowing, and the fertilizer thus thoroughly incorporated with the soil before the appearance of the grapes, there is absolutely no danger that the wine will acquire bad odors from this source. The chief danger to the quality of the wine from injudicious fertilizing is that by applying highly nitrogenous manures the vegetation of the vine may be so stimulated as to give a large quantity of watery and insipid grapes, which are incapable of producing a wine of high quality.

COMPARISON OF METHODS OF SUGAR ANALYSIS AS APPLIED TO GRAPE JUICE (MUSTS).

By Geo. E. Colby.

The determinations of sugar (of which the results are tabulated below) were made simply to determine how far the results obtained by the *volumetric* method, used here already some thousands of times, are comparable with those afforded by some of the *gravimetric* methods. In an Experiment Station like this where so many sugar determinations must be made, it is necessary to use an expeditious as well as an exact method, thus forcing us to reject the gravimetric methods for all ordinary work. Moreover, it sometimes occurs that we are called upon to certify to the amount of sugar in commercial products (for instance condensed must) which may appear in other markets. The English and German chemists would, we are reliably informed, use one or more of the gravimetric methods for determining the sugar in these materials.

*The acidity of the pomace should be neutralized by lime before it is applied to the soil. Many attempts have been made to treat the canes in some manner which would more completely utilize their fertilizing properties than by burning them, but the *schemes* advocated are all more or less expensive, tedious, and in general unsuccessful.

(*a*) *Volumetric*, or method used here for sugar determination in juices of fruits, in wines, etc. This method is printed in U. S. Department of Agriculture, Division of Chemistry, Bulletin 35, page 207, and is practically Soxhlet's volumetric method, although modified here so as not to use so much copper solution. Fehling's solution used is made as described in the above-named report, page 106. The amount of juice taken, addition of lead acetate, and dilutions to reduce to 1 per cent sugar solution, are as follows for grape juice: 150 cc. juice plus 20 cc. basic lead acetate, filter; to 50 cc. filtrate from above mixture add 50 cc. of either a 10 per cent sodium carbonate or 50 cc. fresh SO_2 (sulphurous acid) solution for the removal of lead; then dilute filtrate from lead, in all ordinary musts, *ten* times, and titrate this last solution exactly against 10 cc. of Fehling's solution. The percentage of sugar in juice is then easily calculated from the above data, counting 10 cc. Fehling's solution as worth 0.05 gram sugar (cane sugar has not been found in juices of grapes here when tested for).

(*b*) *Gravimetric Methods.*—Both the methods, *reduction of cuprous oxid*, and *electrolytic*, are given in report named above on pages 207–212. The juices used in this work were measured. The results, given below, speak for themselves.

Results Obtained by Different Methods of Analysis.

Number and Name of Sample.	Solid Contents of Juice, by Spindle—Per cent.	Volumetric Method.	Gravimetric Methods.	
		Fehling's Solution—Per cent.	Reduction of Cuprous Oxid—Per cent.	Electrolytic—Per cent.
2021. Black Ferara	26.60	25.25	25.57	25.28
2024. Black Morocco	21.50	19.54	19.72	19.36
2023. Almeria	24.35	22.67	22.87	22.75

FRUIT AND FRUIT SOILS IN THE ARID AND HUMID REGIONS.*

By E. W. Hilgard.

I desire to bring before this audience some points relating to the researches of the Experiment Station, and particularly the differences we have found in comparing European and Eastern results with ours.

It is so often attempted to apply the data obtained and the practice prevailing in humid climates to our conditions, that it seems desirable to outline distinctly some of the main differences already established between the arid and humid regions as regards the natural conditions of agriculture and horticulture and the products obtained.

"Arid" means an irrigation country with scanty rainfall, and no summer rains. When we review the list of such countries we find among them those having developed the oldest civilizations—Egypt, Syria, Persia, India; in America the Mexican plateau, Peru, and Chili. Why did those people choose lands apparently so uninviting, requiring laborious irrigation, instead of going where nature provides an abundant rainfall?

* Lecture delivered at the Horticultural Convention held at Los Angeles, 1893.

Average Composition of Soil.—The following table contains, I think, some of the fundamental facts that have determined their choice. This table shows the generalized results of about eight hundred analyses of soils of the southern and western United States, selected with a special view to their representative character; all samples having been taken in like manner, and all analyses made by the same method. It is by far the largest series of such analyses that has ever been made in a uniform manner and from so large an area; it therefore offers the first opportunity for comparison between the soils of widely different climatic regions, on a sufficiently extensive basis to insure results independent of local accidents. It is perhaps necessary to remark here that no comparison is possible between soil analyses made by different methods. You can get from one and the same soil a score of different results by varying the method.

Let us see wherein the differences between the soils of the arid and humid regions chiefly consist.

	Humid Region.		Arid Region.	
	Average of 466 Soils.		Average of 313 Soils.	
Insoluble matter	84.031	87.687	70.565	76.135
Soluble silica	4.212		7.266	
Potash		.216		.729
Soda		.091		.264
Lime		.108		1.362
Magnesia		.225		1.411
Br. oxid of manganese		.133		.059
Peroxid of iron		3.131		5.752
Alumina		4.296		7.888
Phosphoric acid		.113		.117
Sulphuric acid		.052		.041
Carbonic acid				1.316
Water and organic matter		3.644		4.945
		100.178		99.993
Humus		2.530		
Humus per cent		2.700		.750
Nitrogen per cent in humus		5.450		15.870
Nitrogen per cent in soils		.122		.101
Hygroscopic moisture		4.650		6.281
Absorbed at		18.5°C.		15°C.

Considering, for the present purpose, only the mainly important ingredients, namely, those which we have to replace by the use of fertilizers, we see that in the case of *potash*, the soils of the arid region exceed those of the humid in the proportion of more than three to one; and nearly the same is true of *soda*.

As regards *lime*, we see that the proportion is a much higher one—nearly fifteen in the arid to one in the humid region. In the case of *magnesia*, nearly five and a half to one. As to the condition of these substances—their relative availability as plant-food to be drawn upon by crops—the item above, "soluble silica," shows that their easily decomposable compounds are more abundant in the arid soils to the extent of at least one half more.

As regards one of the most important ingredients—*phosphoric acid*—the table shows that there is no material difference on the average; a result to be expected on chemical grounds.

Concerning humus, which among other points involves the supply of nitrogen, the most costly of all to supply in fertilizers, the table would seem to show a difference very much against the arid soils. But as will be seen, this difference is more apparent than real.

The cause of the main differences is simply that in the arid region the rainfall is insufficient to wash the soluble portions of the soil through into the country drainage; while in the humid region the soil is constantly being leached by the rains, especially by those of summer. Thus both potash and soda—very soluble in water, as you know—are left in the soils of California partly in the soluble form, partly in that of new combinations, from which the roots of plants can readily absorb them. The easily soluble parts we call "alkali." In sea-water we have the most general outcome of the leaching of the land; but before these leachings reach the sea they are so far changed in their nature that most of the lime and potash remains behind, while most of the soda passes forward and forms "sea-salt."

We find, then, that the prominent difference between the soils of the humid and arid regions consists, throughout, in a very large average excess of lime, and a smaller but still very decided excess of potash in those of the arid region as compared with the humid.

Lime.—The excess of lime is so large as to place all the soils of the arid regions in the class of limy or calcareous soils. Now, in the humid regions of the East and of Europe, it is an adage that "a limestone country is a rich country." As all arid soils are virtually limestone soils, it follows that "arid countries are rich countries." And right here seems to be the explanation of the preference the ancient nations had for arid or irrigation countries.

Liming, of course, can do no good to land that is already limy to the extent to which lime is useful in soils. This has been the experience of California, apart from exceptional cases mostly of unusually heavy soils. Of course, marls containing other useful substances (*e. g.*, phosphoric acid) may nevertheless be good fertilizers.

Potash.—What is true of lime is also, in a great measure, true of potash. It is true that the excess of potash in the arid soils is not as great as in the case of lime, but the fact that dissolved potash is all but universally present in the alkali salts that we find everywhere, whether in the low grounds in the form of alkali spots or crusts, or in the waters of the streams that come from and leach out the uplands, admonish us that the need of artificial fertilization with potash must be the exception, and the contrary the rule. In proof of the facts alleged, I call attention to the table (see folder, p. 135), which shows the composition of the alkali salts at various points in this State, and one at least out of many I have examined from the State of Washington.

You perceive that a very considerable percentage of all these "alkalies" is potash; and in soils impregnated with them the aggregate amount is many times larger than you would dream of introducing in the form of potash salts as fertilizers. To do so would evidently be to "carry coal to Newcastle." And so long as the alkali salts are being washed out of the uplands by the winter rains—and that is just where the alkali comes from—it is not probable that the uplands themselves will need replenishment of their potash until they shall have been cropped heavily for some time. But that is question of fact, easily tested by an experimental application of potash. Such tests made at our stations have in all but

one case proved the inefficacy of potash fertilization; that one case was foreseen by the fact that the analysis of the soil showed it to be very poor in potash. But such cases seem to be quite rare, as is shown by the general average for California soils, given in the table. In regions long settled and heavily cropped, of course potash will gradually become a needful and efficient fertilizer.

Phosphoric Acid.—Phosphoric acid is not, as the table shows, among the substances favored by aridity; its supply is independent of climatic causes on account of its insolubility in the soil. The detailed table also shows that California soils are rather behind in the average contents of this substance; hence phosphates have proved preëminently effective in the great majority of cases—not of course in those in which alkali, like some that is shown in this small table, impregnates the soil.

Nitrogen.—As regards the other important element of plant-food, nitrogen, the small table shows that in some cases—in most alkali soils—it is exceedingly abundant in the soil in the form of nitrates; which as is well known form rapidly in arid climates, since from these our supply of commercial nitrates comes. Chili and Nevada are in point. But these nitrates have the disagreeble property of being very easily washed out of the soil by rains or irrigation; therefore the uplands may require fertilization with nitrogenous manures even though the alkali in the lowlands may contain abundance. There are, however, some peculiar points still under investigation, tending to show that there are compensating agencies which, even in the uplands, render the nitrogen-supply relatively easy under arid conditions. Briefly stated, the fact seems to be that the humus of arid soils is so much richer in nitrogen than in the humid region, that the average amount in the soils is nearly the same in both regions; and that it is more readily available to plants in the arid climates.

COMPOSITION OF CALIFORNIA FRUITS.

So much for the *soils* with which California fruit-growers have to deal, and which, as you perceive, are quite materially different in character from those of the regions of summer rains. That the same is true in a measure also of the *fruits* grown upon them, can be perceived by the palate alone, when you have them at hand for comparison. But as this is not often feasible, and as tastes will differ, we have gone to a great deal of labor in investigating the composition of California fruits. I may say of this work, as of that on soils, that for the fruits examined, we have now at our command a larger series of fruit analyses than are on record from all the countries of Europe combined. Here is a tabular statement of the analyses made thus far:

Summary of Number of Fruit Analyses Made at Agricultural Experiment Station, 1880 to 1893.

	No. of Samples Examined to December, 1892.		Crops of—
Citrus Fruits (92 samples)—			
Oranges	130		
Lemons	45		
Total		175	1891, 1892, 1893.
Stone Fruits—			
Prunes	36		1891 and 1892.
Apricots	14		
Plums	3		
Peaches	2		
Nectarines	1		
Total stone fruits		56	
Olives		26	
Figs		41	
Grapes (Musts)		2,136	1880 to 1893.
Wine		1,500	1880 to 1893.
Total		3,934	

This multiplicity of analyses enables us to give reliable averages for a number of fruits of which only a few analyses are reported from Europe. So far as these enable us to make comparisons, there are very serious differences in the composition of many of the fruits, both as regards the proximate ingredients (such as sugar, acid, albuminoids or flesh-forming ingredients, etc.), and with respect to the ash composition, which bears particularly upon the draft they make upon the soil. Here are a few data referring to the first class of ingredients, which bear specially upon the taste and nutritive value of the several fruits:

Percentages of Sugar and Acid.

(From Bulletins 97 and 101.)

No. of Analyses.	Fruits.	California.				Europe.
		Juice.		Flesh.	Whole Fruit.	
		Acid—Per cent.	Sugar—Per cent.			Sugar.
11	Apricots	.68	13.31	11.93	11.10	10.0
23	Prunes	.40	20.00	16.11	15.35	6.2
13	French prunes	.31	23.69	19.70	18.53	.....
3	Plums	.48	17.97	13.25	12.89	3.6—7.0
2	Peaches (from Shasta and Butte Counties)	.24	17.00	13.40	12.50	2.0—4.5
1	Nectarine	.62	17.17	15.13	14.11	.....
	Grapes from various localities	.50	24.00	23.00	20.70	14.40
80	Oranges from various localities	1.28	10.68	7.12	5.40	4.60
2	Figs (White Adriatic) from Kern and Fresno Counties	.15	23.90	.....	19.20	11.50

Average Percentages of Albuminoids.

No. of Analyses.	Fruits.	In Whole Fruit—Total.	In the Fresh Flesh, or Edible Portion.	In Fresh Pits or Rind.
			Calculated upon Whole Fresh Fruit.	
	ORANGES.			
35	California	1.140	.760	.380
----	European (Sicilian)	1.780	----------	----------
	APRICOTS.			
11	California	1.250	1.088	.162
----	European	.490	----------	----------
	PRUNES.			
20	California	1.012	.837	.175
----	European	.780	----------	----------
	PLUMS.			
3	California	1.130	1.000	.130
----	European	.400	----------	----------
	APPLES AND PEARS.			
----	European	.375	----------	----------
	FIGS.			
2	California (White Adriatic)	1.500	(1.50)	----------
----	European (Smyrna)	1.420	----------	----------
----	NECTARINES	.731	.625	.106

Comparison of Proximate Ingredients.—Thus we have in the case of the apricot, 12 per cent of sugar against 10 in the European fruit; in the case of prunes, 16 against 6 and a small fraction; in plums, 13½ against about 5; peaches, 13 against 4½; grapes, 23 against 14½; oranges, 7.12 against 4.6; figs, 19 against 11½. In most of these cases there is a corresponding excess of acid in the European fruits. That such considerable differences must influence materially the palatableness of the product, as well as its digestibility and nutritive value, is manifest.

But no less serious, and perhaps more directly affecting the nutritive value, are the differences in the contents of the flesh-forming ingredients—the "albuminoids." Here we have in the case of the apricot a proportion of 5 for the California product against 2 in the European; in the prune, 5 to 4; in plums, 11 against 4. For figs also the difference is slightly in favor of the California product; while singularly enough, in the case of oranges the difference is the other way, in the proportion of about 11 to 18.

Thus, aside from the orange, all of our fruits thus far examined exceed considerably the European fruit, both in sugar and flesh-forming substances, greatly to the advantage of their nutritive value. For the orange, while the sugar is also in excess with us, the flesh-forming ingredients are relatively less.

It will thus be seen that both as regards the contents of sugar, acid, and albuminoids, there are differences which in some cases amount to over 50 per cent of the figures found for California fruits.

Comparison of Ash Composition.—Differences nearly as great occur in the ash composition.

Soil Ingredients Extracted by Different Fruit Crops.

Fruits.	Total Ash—Pounds.	Potash—Pounds.	Phosphoric Acid—Pounds.	Nitrogen—Pounds.
GRAPES.				
European—				
In each 1,000 pounds	8.8	5.00	1.52	1.70
	4.90			
APRICOTS.				
European—				
In each 1,000 pounds				.86
Crop of 30,000 pounds	147.00			25.80
California—				
In each 1,000 pounds	4.91	2.90	.64	1.94
Crop of 30,000 pounds	147.30	87.00	19.20	59.20
PRUNES.				
European—				
In each 1,000 pounds	6.3	3.73	.95	1.22
Crop of 30,000 pounds	189.00	111.90	28.53	36.60
California—				
In each 1,000 pounds	4.86	3.10	.68	1.62
Crop of 30,000 pounds	145.80	93.00	20.40	48.60
PLUMS.				
In each 1,000 pounds	5.35			1.81
ORANGES.				
European—				
In each 1,000 pounds	6.07	2.78	.67	2.69
Crop of 20,000 pounds	121.40	55.60	13.40	53.80
California—				
In each 1,000 pounds	4.32	2.11	.53	1.83
Crop of 20,000 pounds	86.40	42.20	10.60	36.60
FIGS.				
European—				
In each 1,000 pounds	8.00	2.27	.10	2.27
Crop of 15,000 pounds	120.00	34.05	1.50	34.05
California (White Adriatic)—				
In each 1,000 pounds	7.81	4.69	.86	2.38
Crop of 15,000 pounds	117.15	70.45	12.90	35.70

Thus, as regards *potash*, we find in California prunes only 93 pounds of potash per acre for a 30,000-pound crop, while for Europe the figure is 112. For oranges the corresponding figures (20,000 pounds per acre) are 86 against 121; for figs, the figures are nearly identical. The general result is that the potash is uniformly less in California fruits than in the European.

For *phosphoric acid* we find some very striking differences, amounting in the case of the fig to a proportion of nearly 9 in the California to 1 in the European. For oranges the difference in the same direction is as 13 to (nearly) 11; in prunes, as 95 to 68. We find, then, as regards phosphoric acid, that California fruits draw more heavily upon the soil than do European ones. Since (as I have shown) California soils are rather deficient in that substance, this is a significant indication for the horticulturist.

But in this respect even greater significance attaches to the *nitrogen* contents of these fruits, which, as already shown, is considerably greater in California fruits in all but the orange. Thus an average crop of California apricots takes out of the soil nearly 60 pounds of nitrogen against about 25 in the European; prunes, 49 pounds against 37 in Europe. In figs there is only a slight difference; in the case of oranges, the California takes only 37 pounds against 54 in Europe.

European Data and Rules Not Always Applicable to California.—Such differences as these should warn us against taking for granted that in our climate and in our soils the data and rules transmitted to us from

Europe and from the East are applicable; the more as we have our own data in a much more complete shape than are, thus far, those coming to us from the outside. Our growers as well as our fertilizer manufacturers must take note that what is true for the humid climates, from which most of our data for these matters are derived, does not necessarily hold good in arid climates. By reason of their comparative remoteness from the centers of scientific investigation, the products and soils of the arid regions have until now received but very little attention; and what has been done outside of this State has been mostly done in such a scattering and unsystematic manner as to convey scarcely any data for definite comparison. I am therefore justified in calling the attention of farmers, and especially of fruit-growers, to the fact that Eastern precedents will not serve them in these matters; and that when fertilizers are offered them upon the basis of Eastern or European data they should consult first the facts elicited for them by the State Experiment Station, in order to see that their money is spent to the best advantage. Much remains to be done, but what has been done is at least worthy of their close attention.

The reports and bulletins of the Experiment Station are sent free to any citizen of California making application therefor.

II.

REPORTS

ON

CULTURE WORK AT THE EXPERIMENT STATIONS.

A. *Central Station;* Alameda County.
B. *Foothill Station;* Amador County.
C. *Southern Coast Range Station;* San Luis Obispo County.
D. *San Joaquin Valley Station;* Tulare County.
E. *Southern California Station;* Los Angeles County.
F. *Forestry Stations;* Chico and Santa Monica.

Two New Wheats now on Trial at Central Station.

REPORTS ON CULTURE WORK AT THE SEVERAL EXPERIMENT STATIONS.

A. CENTRAL EXPERIMENT STATION.

Berkeley, Alameda County.

OUTLINE OF OPERATIONS UPON THE GROUNDS OF THE CENTRAL STATION.

By EDWARD J. WICKSON.

Every effort has been put forth during the past year to accomplish as much as possible with the reduced amount of money apportioned to this department. Increased public interest in the outdoor features of the work at Berkeley has naturally stimulated us to extension of cultures. The requirements of the outlying stations in the way of materials for planting has brought upon the Central Station an amount of propagation far greater and more diverse than was ever undertaken before. Our new efforts seemed to make it necessary that we should have a more liberal allowance of funds for labor at this Station, and certainly more money could have been well expended; in order to meet the new requirements we have been obliged to forego many desirable improvements, and defer items of equipment which are sorely needed. In fact, we have been obliged to figure very closely to secure maintenance and avoid retrogression. In this connection I desire to make special mention of the services of Capt. Emil Kellner, foreman of the agricultural grounds. His management of the affairs intrusted to him is to be largely credited with the efficient and economical use of labor and material which has been secured.

Cereal and Forage Plant Collections for Exhibition.—A full illustration of the efforts of the Station in the collection of varieties of cereals and forage plants was made at the Columbian Exposition and at the Midwinter Fair, as mentioned in the account of these exhibitions in another portion of this report. To secure the material, the full collections were freshly grown; fertilizers were used. The season proved favorable, and very fine specimens were secured. The growth and assortment of material, packing up, and labeling required much time, and still must be considered well employed, for the collections as shown at these great exhibitions won wide commendation, and brought this feature of the work of the Station to the attention of many people hitherto unaware of it.

Records were kept of observations on the growth of the different cereals, which in the main agreed with the data published on pages 138 to 144 of our Report of 1891–2.

The cereal collection has been largely increased during the last two years, and distribution has been made to a limited extent, from which reports are expected in time for the next report from the Station. An engraving given herewith shows two of the most promising varieties: The Northern Champion and a cross-bred wheat—Hornblende x Ward's White—the latter being one of a series of hybrids originated by William Farrer, of New South Wales, and sent to this Station for trial. Just now, interest in improved and more productive wheat varieties seems to be increasing in this State, as noted elsewhere.

Propagation for Distribution and for Planting at Outlying Stations.—In another part of this report an outline is given of the work of distribution of plants, seeds, cuttings, and scions to voluntary experimenters throughout the State. The extent of the propagation required to furnish materials for this distribution, and to supply also stock for planting at the six outlying Stations, made it necessary to enlarge our propagating grounds. This was done by establishing a new nursery in the northwest corner of the agricultural grounds. The land was deeply and thoroughly worked, properly laid off, and furnished with facilities for irrigation. Upon this ground large collections of Persian and Italian grape varieties have been propagated. It is intended to have always ready on this ground budding and grafting stocks suitable for all kinds of fruits of which we are now receiving buds and scions from originators in different parts of the world.

The Garden of Economic Plants.—This interesting and popular portion of the agricultural grounds has been maintained, in the main, upon lines previously followed. There has been, however, some change in the allotment of the ground. Plants which have been grown long enough to demonstrate their characteristics and adaptations have been reduced to small specimen plots and larger space given to newer plants. The plots devoted to grasses and forage plants have been largely resown. The annexes to the garden planted two years ago are now in very satisfactory condition. The one given to the collection of wild grapes from different parts of the world, grown on trellises, as required by their habit of growth, is now one of the most attractive features of the grounds. Much re-labeling has been done in the garden during the last year. It also became necessary, through the washing of the creek bank, to put in a temporary restraining wall, which was done by driving posts at the base of the bank, interweaving willow branches, forming a sort of heavy wickerwork. Behind this the space was filled with good soil, in which the willow branches rooted readily. This growth promises to bind the whole structure firmly to the bank and to remove the menace to some of the most valuable trees along the top of the bank, at least for the present. In this connection it must be noted that an embarrassment and trouble which has not been grievous hitherto is now becoming serious and some effective steps must be taken for its reduction. Both in the Economic Garden and in other parts of the grounds we are experiencing considerable losses through plant thieves. The growth of Berkeley as a city, and the multiplication of methods of quick transit, are making the University domain more and more a public resort. Unfortunately, many dishonest persons are now appearing, who do not hesitate to break off parts of plants or even pluck them out by the roots if they are at all attractive or novel. We have been obliged to plant out many of our newest things without labels, because the discriminating

View, looking west, in the GARDEN OF ECONOMIC PLANTS, showing style of Culture plots.

GARDEN OF ECONOMIC PLANTS, CENTRAL STATION. View from the west.

thieves seem to know well what is most desirable. It has also been necessary to keep watchmen employed on Sundays and holidays during a great part of the growing season, but the thieves watch the watchmen and take advantage of every moment of temporary absence. As it would not be fair to the general public to exclude them from the experiment grounds, and as their exclusion would seriously impair our efforts, which naturally court public interest, it seems likely that more efficient and extended police patrol must be provided and vigorous prosecution of trespassers adopted. Possibly in this way dishonest persons may be made to show greater respect for the public interest and public property.

A partial view of the Garden of Economic Plants, showing a number of culture plots, is given herewith in an engraving from a photograph by Dr. Loughridge. Another is from a plate kindly loaned by the *Overland Monthly*.

Field and Orchard.—These parts of the grounds have had due attention during the year. Some useless trees have been removed and many new varieties of different fruits have been planted. A large amount of stable manure has been secured without cost, except that of hauling with our own team, and it has been used to good advantage. The value of such dressing to old trees in such lean and shallow soil as we have in Berkeley is very apparent. The treatment of the stable manure gathered from various sources has been to hold it for several months in large piles, applying water enough to keep the mass moist, and using dry earth or gypsum as a cover to render the fermentation inoffensive and to retain the matters which might otherwise be lost in the atmosphere. The application of this manure to the field on which oat hay has been grown for several years produced a notable improvement in this year's yield, although the season was unfavorable.

TWIG-BUDDING AND GRAFTING THE OLIVE.

The popularity of the olive clearly appears in the public interest taken in the introduction and propagation which we have been carrying on for several years, and of which preliminary mention has been made in earlier reports. Captain Kellner had made special effort to inform himself on these varieties and the feasibility of working them upon stocks of inferior varieties which many growers wish to transform. Of his experience in budding he furnishes the following note:

I find twig-budding to be the best manner of changing seedling or inferior olive varieties to good ones. The operation can be performed at any time of the year when the bark will peel and the twig-buds are in proper condition. If done late in the summer the buds lie dormant until spring. Good results can be obtained by budding in the spring, as the operation can be performed to a better advantage, and the buds will make growth the first summer. When the operation is performed on large trees, the top should be only partly removed until the twig-bud has made some growth, when the whole limb may be removed, leaving say eight or ten inches to tie the young shoot to. After a year remove the whole limb, make a smooth cut and use some grafting compound to heal the wound. The bud or twig-bud to be used should be hard, that is the young shoot should be matured. The bud should be cut deep into the wood, the leaves should be partly cut off, then with the sharp point of the budding-knife the greatest part of the wood should be removed. After removing the wood from the bud, place the same in the T incision, as done in common budding, tying with cotton twine or "raffia," and afterwards with a strip of waxed cloth to keep out the air and moisture.

Grafting can be done also in the spring—March and April. The scions to be used in grafting should be cut during the dormant state of the olive tree in winter, and heeled-in in sand to keep them alive. In using the wedge graft care should be taken not to split the limb to be grafted further than necessary for fitting the scion. Grafting by approach has been done at this Station to secure trees for our outlying stations. This will show the character of the fruit sooner than can be had with trees raised from cut-

tings. A frame was built around the varieties to be used, and seedling olive trees in pots were placed on it. A shoot to be used as a scion was bent down to the seedling, a common whip graft made on this shoot, a corresponding cut made on the seedling; the two are interlocked and tied. The scion is connected with the parent tree, and after the graft has made a growth, it is partly cut off, so as to have the graft sustain itself. By degrees the whole limb is cut off and the tree is ready for transplanting.

THE LOGAN BERRY.

No single fruit has excited more interest among visitors to the Station grounds than the Logan berry. A few plants were donated to the Station by the originator, Judge J. H. Logan, of Santa Cruz, several years ago. Its splendid size, prolific bearing, and notable excellence as a table fruit when thoroughly ripened, convinced us of its unique character and exceptional value as a new fruit. Plants were propagated as far as was possible under the limitations of the habit of the variety, which is to multiply by growth from the tips like the Black Cap class of raspberries, though, of course, layering of the whole cane multiplies the plants. Growth from cuttings is not satisfactory as a rule. The plants were first offered to the public in Bulletin No. 102 of this Station, issued in December, 1893, although it had been privately disseminated previously to a limited extent. The largest grower, Mr. James Waters, of Watsonville, has successfully marketed the fruit for several years, but did not offer the plants for sale until after our announcement. Our description of the fruit attracted much attention at the East, as well as in this State, and we could only supply a small number of those who applied to us for plants.

The Logan berry is an exceedingly robust grower, and has unique foliage and cane growth as well as fruit. All of these are indicated in the accompanying engraving, from a photôgraph by Dr. Loughridge, of fruit grown upon the Station grounds. The fruit is strikingly large and handsome, and a laden cane is a sight not to be forgotten. The fruit is sometimes an inch and a quarter long, with the shape of a blackberry, and sometimes the hue of a dark-red raspberry. Its flavor is unique and peculiar, and gives to many tastes suggestions of the combination of blackberry and raspberry flavors. So far the vigor of the growth of the plant seems to give it freedom from leaf disease of all kinds. For our coast and valley climates, so far as tried, it shows perfect adaptation. How far it will withstand the heat and drought of the interior or the freezing of wintry climates can only be told by the trial which it is now receiving under almost all conditions.

Concerning the origin of this remarkable fruit we cannot do better than introduce the following account, written by the originator, in his correspondence with this Station, under date of August 12, 1891:

The berry is a cross between the Aughinbaugh blackberry (a wild berry found by a Mr. Aughinbaugh, of Alameda, near the bay at Schutzen Park) and an old raspberry that Id o not know the name of. It is a very common berry here and belongs to the French type of raspberry. The Aughinbaugh stood between a row of the Crandall or Texas Early and the raspberry named. I gathered the seed and planted it in the fall of 1884, in tending to get a cross between the Crandall and Aughinbaugh. I did not think such a thing as a cross between the raspberry and blackberry possible. I have never attempted to do anything with it commercially, but it has borne abundant and regular crops ever since. The berry has been grown from seed several times and the result in every case has been a true redberry. I suppose a thousand seedlings have been grown from this plant, and I have never heard of a single instance of a seedling resembling either the raspberry or the blackberry; they are not all as good as the parent, but they are all true redberries. This shows that the berry has come to stay. That it is an entirely new and distinct berry I have no doubt. It is known and grown all over this county as the Logan berry. (J. H. LOGAN, Santa Cruz.)

LOGAN BERRY (natural size) grown on the Station grounds Berkeley.

THE NEW PLANT HOUSE.

At this writing (July, 1894) the foundations for the new plant house of the Agricultural Department are being laid. The facilities which this building will afford have long been greatly needed. The old wooden houses which were erected for temporary purposes almost twenty years ago were always too small to meet the demand for propagation, and too low to admit of the growth of even ordinary specimen plants. During the last few years, when our introduction of exotics and multiplication of them for distribution and for planting at outlying stations has so largely increased, the old houses have become painfully inadequate. It is with great satisfaction, therefore, that we report the progress of work on the new plant house, an engraving of which is given herewith. The plant house was designed by Lord & Burnham, of Irvington, N. Y. The materials of the superstructure are iron and glass throughout, no wood being employed except for doors, and cap and sash bars, which come immediately in contact with the glass. The plant benches will be of iron and slate of the most modern style of construction, and the hot water heating apparatus will also be of a pattern approved by recent comparative tests. In these respects we expect that the new range of houses will be a model of this class of structures, and will be an example to those contemplating green-house building.

The new plant house is situated upon the slope between the Students' Observatory and the Botanic Garden. This location is desirable, because of higher temperatures secured by elevation, and it will also bring the building into view from the main portions of the campus and the other buildings of the University. The range of buildings fronts south. The extreme length is a little more than 170 feet, and the greatest depth will be 87 feet. The total interior area will be upwards of 7,000 square feet. The dimensions of the several portions of the range, as shown on the ground plan accompanying, are as follows: Vestibule, 10x12 feet; palm house, or central portion, 45x45 feet, with a clear height of dome of 42 feet; extensions on each side of the palm house, 20x37½ feet, 14 feet high; wings on each end of the range, 25x60 feet, 16 feet high. Thus the main structure consists of five apartments inter-communicating and still isolated so as to admit of the maintenance of different temperatures as required for the different classes of plants. In the rear of the palm house is a building 29x30 feet for office, potting shed, and heating furnaces. It is anticipated that the building will be ready for occupation before the close of the present year. The building and its appurtenances will cost about $13,500.

THE UNIVERSITY BOTANIC GARDEN.

By J. Burtt Davy, of the Department of Botany.

The arrangement of the paths in the Botanic Garden, as detailed on the plan given in the 1891–2 Report, p. 167, having proved inconvenient, because somewhat obstructing ready access to the various flower-beds, it was considered advisable to make the necessary alterations before the rapid growth of trees and shrubs rendered such a course impracticable without much sacrifice of valuable material. This work

has been carried out during the past winter and spring, under the direction of Mr. Ivar Tidestrom, Student-Assistant in the Department of Botany, upon a design of his own preparation. The consequent transplanting, though undertaken rather late in the season, has on the whole proved very successful.

New ground has been broken between the path leading to the observatory and that leading to the new Mechanics Building, but the arrival of the dry season made it advisable to desist from planting until the fall rains. It is expected that the remaining unbroken ground will be brought under cultivation during the coming winter.

A rockery for the cultivation of ferns and other plants needing cool shade and constant moisture is being formed under the shade of trees at the southwest corner of the garden. The nucleus of a collection of Californian ferns has already been planted here, and the probable success of this experiment in the culture of these attractive plants in a region which is normally too dry for most of the species, seems assured by the supply of water laid on to the lower portion of the garden last May. Mr. Henry Melde, of Eureka, Humboldt County, has generously sent ten fine roots of the Deer Fern (*Lomaria spicant*) which will be planted on the rockery as soon as it is ready to receive them.

Owing to the depredation of visitors it has been found necessary to fence-in about half an acre of the best ground, where the rarer and more beautiful flowers can be propagated and experimented upon without interference. The mania for stealing roots as well as flowers seems to be seriously on the increase here, and while it is very unpleasant to have to lock up plants where they cannot be seen except by visitors under escort, it has become necessary to do so in order to propagate and carry on experiments with plants which are often obtainable only at great expense of time and money.

Native Plants.—The valuable collection of native plants has been augmented by nearly two hundred packets of seeds collected in Modoc and Lassen Counties by Mr. Milo S. Baker; several packets from Mount St. Helena, Napa County, and Mount Shasta, collected by Mr. Willis L. Jepson; some especially desired rarities in the way of plants and seeds from Sonoma County, from Mr. F. T. Bioletti; thirteen packets of seeds from Humboldt County, collected by Mr. C. C. Marshall and presented by Mr. Chas. Weck; and several packets of seeds, and roots of plants collected by the writer around New Almaden, Santa Clara County, and Olema, Marin County.

Seed Exchange.—This important work has been considerably extended this year, no less than 1,950 packets having been sent out; almost all of these were distributed among the following institutions:

Department of Horticulture, Cornell University, N. Y.
Royal Gardens, Kew, England.
Royal Botanic Garden, Edinburgh, Scotland.
University Botanic Garden, Utrecht, Holland.
University Botanic Garden, Liège, Belgium.
University Botanic Garden, Parma, Italy.
University Botanic Garden, Tokio, Japan.
Botanic Garden, Florence, Italy.
Botanic Garden, Berlin, Prussia.
Botanic Garden, St. Petersburg, Russia.
Botanic Garden, Munich, Bavaria.
Botanic Garden, Glasgow, Scotland.
Botanic Garden, Upsala, Sweden.
Botanic Garden, Copenhagen, Denmark.
Botanic Garden, Durban, Natal.

Botanic Garden University of California.

Botanic Garden, Melbourne, Victoria.
Botanic Garden, Brisbane, Queensland.
Botanic Garden, Cape Town, South Africa.
Botanic Garden, Wellington, New Zealand.
Argotti Botanic Garden, Malta.
Jardin d'Acclimatation, Geneva, Switzerland.
Royal Botanic Gardens, Seebpore, Calcutta, India.

Valuable collections of seeds have been received in return from the following places: Melbourne (the generosity of Sir Ferdinand von Mueller, the Government Botanist of Victoria, keeping us constantly supplied with freshly collected seed of valuable Australian plants), Cape Town, Helsingfors, Geneva, Kew, St. Petersburg, Durban, Florence, Utrecht, Edinburgh, Copenhagen, Tokio, Parma, and Malta.

DISTRIBUTION OF SEEDS, PLANTS, CUTTINGS, ETC.

By Edward J. Wickson.

The distribution of materials for trial by voluntary experimenters, which has been conducted by this Station ever since its establishment, has during the last three years attained an extent considerably greater than before. In the Report for 1890 summaries of this distribution are given for the five years preceding. Below are tables covering transactions since the Report for 1890, with totals of earlier distribution. University Bulletins Nos. 95, 98, and 103 give in detail the offerings of the years 1891 to 1893, inclusive. It is not desirable to reproduce these *in extenso*, as there is necessarily some repetition in the annual announcements. It will be better to present accounts of the plants in connection with notes from the reports received from our correspondents, and these will be found on following pages.

Concerning the plan of distribution, there is still some lack of apprehension on the part of the public, and to reduce this we reproduce the following statement:

Distribution is undertaken for the purpose of securing a popular verdict on the value and adaptability in all parts of the State of the growths which we have under observation on the grounds of the Central Station at Berkeley, and of the four outlying stations in Amador, San Luis Obispo, Tulare, and Los Angeles Counties. With this purpose in view, our distribution contemplates the acceptance of an obligation by the applicant to faithfully experiment with the material supplied, and to report success or failure. That this obligation is conscientiously discharged by a large proportion of our correspondents is shown by the full data credited to such sources in our recent reports. This distribution from the Station is for the purpose of securing wide trial of growths new to the State, and does not include common trees, plants, and seeds which can be had from dealers. For this reason, we do not invite applications for general supplies of garden seeds or fruit trees. We cannot furnish them. We cannot undertake distribution to citizens of other States, except where desirable exchanges are offered.

Number of Plants and Cuttings Distributed.

Name.	Total. 1886-91.	1891-92.	1892-93.	1893-94.	Total.
Trees—Black wattle	185		114	38	337
Guava	303				303
Kikar	205				205
Olive	1,028				1,028
Camphor	985				985
Cork oak	803				803
Date palm	244				244
Melon	92				92
Strawberry	212				212
Sumac	46				46
Tea	108				108
English oak	470			38	508
Kai apple	408				408
Carob	136				136
Ironwood eucalyptus*			108		108
Lemon-scented gum			177	42	219
Balm of Gilead fir*				19	19
Western arbor vitæ				19	19
Austrian pine				21	21
Drooping cypress				23	23
White pine				20	20
Lawson cypress				17	17
Kentucky coffee tree				44	44
Eastern black walnut				48	48
Carolina poplar				28	28
Hackberry				34	34
Black ash				7	7
Pawlonia				40	40
Catalpa				38	38
California maple				58	58
Fiber plants—Esparto grass	210	50			260
New Zealand flax	470	30			500
Ramie	650	120			770
Forage plants—Australian salt bush	490				490
Texas blue-grass roots	8,370	504		456	9,330
Flat pea roots			1,610	1,610	3,220
Plants—Bamboo	666				666
Caper	501				501
Licorice roots	285				285
Taro		159			159
Jerusalem artichokes		1,680			1,680
Sugar cane		57		90	147
Logan berry				76	76
Henna plant				104	104
Cuttings—Grape	10,486	84	462	1,995	13,027
Mulberry	7,415	1,968	900		10,283
Willow	2,150	312	360		2,822
Olive	560				560
Figs			1,272		1,272
Totals	37,478	4,964	5,003	4,865	52,310
Scions—Fruit (number of orders)	232	32	38		302

*Substituted for Hickory wattle and Douglas spruce named in Bulletin.

Weight, in ounces, of Seeds Distributed.

Name.	Total 1886-91.	1891-92.	1892-93.	1893-94.	Total.
Cereals—Wheats	4,912	736	----	2,432	8,080
Barleys	3,584	992	----	----	4,576
Oats	1,536	1,104	----	----	2,640
Ryes	768	----	----	----	768
Buckwheat	56	----	----	----	56
Rice	----	----	----	5	5
Fiber—Flax	1,552	80	----	----	1,632
Cotton	720	104	----	----	824
Jute	88	36	----	----	124
Forage—Grasses—Millet (*Milium multiflorum*)	307	72	----	----	379
Schrader's brome	1,655	128	----	----	1,783
Hungarian brome	1,024	128	----	----	1,152
Japanese wheat	634	176	----	----	810
Tall oat	231	88	----	268	587
Japan clover	86	----	----	----	86
Snail clover	678	92	----	----	770
Kaffir corn	962	----	----	----	962
Yellow millo maize	140	----	----	----	140
Black medic	210	----	----	----	210
Esparcette, or sainfoin	2,080	152	----	----	2,232
Tagasaste	327	----	----	78	405
Hairy-flowered paspalum	210	64	----	----	274
Jersey kale	346	156	----	----	502
Elliott's sida	----	115	116	----	231
Crimson clover	----	----	540	----	540
Wonderful cow pea	----	----	----	115	115
Garden—Corn	2,747	----	----	----	2,747
Peas	572	412	----	----	984
Pumpkins and squashes	421	----	----	----	421
Beans	814	312	126	231	1,483
New Zealand spinach	81	67	57	81	286
Beets	404	79	----	----	483
Carrots	----	61	----	134	195
Trees—Black wattle	555	53	----	----	608
Sumac	22	----	----	----	22
English oak acorns	624	500	----	385	1,509
Sundry—Pyrethrums	809	----	----	----	809
Quinoa	117	----	----	----	117
Chuna	39	----	----	----	39
Tobacco	471	----	----	----	471
Dyer's madder	19	----	----	----	19
Chapman's honey plant	192	----	----	----	192
Anti-gopher plant	----	73	----	----	73
Cañaigre	----	----	40	76	116
Totals	29,993	5,780	879	3,805	40,457

Financial Statement.

	1891-92.	1892-93.	1893-94.
Receipts.			
Coin, stamps, orders, etc., from applicants	$170 98	$203 30	$323 63
Assistance from Agricultural Department of University	4 00	*92 00	12 00
Total receipts	$174 98	$295 30	$335 63
Expenditures.			
Packing material for seeds	$6 10	$2 90	$5 00
Packing material for plants	17 30	21 98	28 36
Postage, cartage, etc.	60 55	25 85	75 34
Stationery	4 31	9 90	6 90
Wages	61 67	*218 26	156 01
Total expense	$149 93	$278 89	$271 60
Amounts of unfilled orders returned to applicants	25 05	16 41	64 03
	$174 98	$295 30	$335 63

*$73 08 was due in 1891-92, but paid in 1892-93.

Extent of Distribution.

	1891-92	1892-93.	1893-94.
Number of applicants supplied	438	410	578
Packages sent by mail	612	517	761
Packages sent by express	46	124	56
Offices	267	225	329
Counties reached	47	46	*48

*The total number of counties in the State in 1893 was 57.

REPORTS FROM VOLUNTARY EXPERIMENTERS UPON PLANTS RECEIVED THROUGH THE STATION DISTRIBUTION.

By Edward J. Wickson.

We are continually gratified with the fullness and frankness which characterize the correspondence connected with the receipt and trial of material furnished by the Station to voluntary experimenters. It is not possible in a report of this kind to make use of all the data furnished by correspondents, but still we count it useful and valuable and desire in every way to encourage our correspondents to give us fully the results of their observations of the behavior of the different plants, together with their conclusions as to their value or otherwise.

Most of the reports below are supplementary of earlier observation given in previous reports, and it is not necessary to repeat our own descriptions and characterizations of the plants there given. If readers of this report desire such information, they can usually obtain it by correspondence with this Station.

CEREALS.

Although the interest in experiments with new varieties of cereals has been greatly reduced by the low market-values of these grains, we *still find some* growers awake to the chance of improvement through

the growth of superior varieties. It is an interesting fact that the notable collections of cereals in variety which were displayed by some counties in the California Building at the World's Fair, and in the county buildings at the Midwinter Fair in San Francisco, were grown from seed furnished from this Station. These displays have naturally called attention anew to our work in securing these collections, and this promises to bring our efforts more prominently before the grain growers of the State than hitherto.

CEREALS AT RANCHO CHICO: *General John Bidwell, Chico, Butte County.*—The appended list will show the varieties that grew, date when sown or planted, date of harvesting and rate of yield per acre. It will be seen that the yield of many samples on the list was so small as to be almost failures. This may have been owing to late sowing, soil, unfavorable season, or other cause. Will try to give them further trial. There were several varieties which failed utterly, viz.: Raub's Black Prolific, Diehl Mediterranean, Winter Fulcaster.

Name of Grain and Variety.	Date when Sown.	Date when Harvested.	Rate of Product per Acre.
Wheat.			
Propo	Jan. 25	July 26	27 bushels.
Pringle's Best	Jan. 25	July 8	24 bushels.
Palestine	Jan. 25	July 25	23 bushels.
Brenner's Winter Eagle	Jan. 25	July 26	23 bushels.
Archer's Prolific	Jan. 25	July 25	22 bushels.
Brenner White Club	Jan. 25	July 27	21 bushels.
Petali	Jan. 25	July 25	21 bushels.
Patent Office	Jan. 25	July 28	21 bushels.
Russian Durmer	Jan. 25	July 27	21 bushels.
Russian Red Bearded	Jan. 25	July 25	20 bushels.
Michigan Mixed	Jan. 25	July 6	19 bushels.
Genoese Winter	Jan. 56	July 27	19 bushels.
Egyptian	Jan. 25	July 26	19 bushels.
Victor	Jan. 25	July 6	19 bushels.
Nonpareil	Jan. 25	July 28	18 bushels.
Red Emmer Spelt	Jan. 25	July 25	18 bushels.
Indian Three Months' Wheat	Jan. 25	July 26	18 bushels.
Pringle's Defiance	Jan. 25	July 29	18 bushels.
Missoyen	Jan. 25	July 17	18 bushels.
Volo	Jan. 25	July 26	18 bushels.
Ghirka or Odessa	Jan. 25	July 29	18 bushels.
White Sonora	Jan. 25	July 25	18 bushels.
Atlanti	Jan. 25	July 25	18 bushels.
Polish	Jan. 25	July 25	17 bushels.
Big Long-bearded Club	Jan. 25	July 25	16 bushels.
Diamond	Jan. 25	July 25	14 bushels.
March Emmer Spelt	Jan. 25	July 27	11 bushels.
Victoria	Jan. 25	July 6	11 bushels.
Brenner's Hungarian	Jan. 25	July 26	11 bushels.
White Beardless Spelt	Jan. 25	July 28	11 bushels.
Red Chaff	Jan. 25	July 29	10 bushels.
Hybrid Dattel	Jan. 25	July 6	9 bushels.
Peru or April	Jan. 25	July 28	8 bushels.
White Emmer Spelt	Jan. 25	July 6	7 bushels.
Hybrid Lamed	Jan. 25	July 28	6 bushels.
Thuringian	Jan. 25	July 28	6 bushels.
Tunisian	Jan. 25	July 28	6 bushels.
White Silesian Spelt	Jan. 25	July 6	6 bushels.
California Spring	Jan. 25	July 27	3 bushels.
Arizona Indian	Jan. 25	July 27	3 bushels.
Frankensteiner	Jan. 25	July 7	2 bushels.
Goldfinder Red	Jan. 25	July 11	2 bushels.
Currell's Prolific	Jan. 25	July 12	1 bushel.
Paine's Defiance	Jan. 25	July 11	.5 bushel.
White Flanders	Jan. 25	July 11	.2 bushel.
Early Clawson	Jan. 25	July 11	.1 bushel.

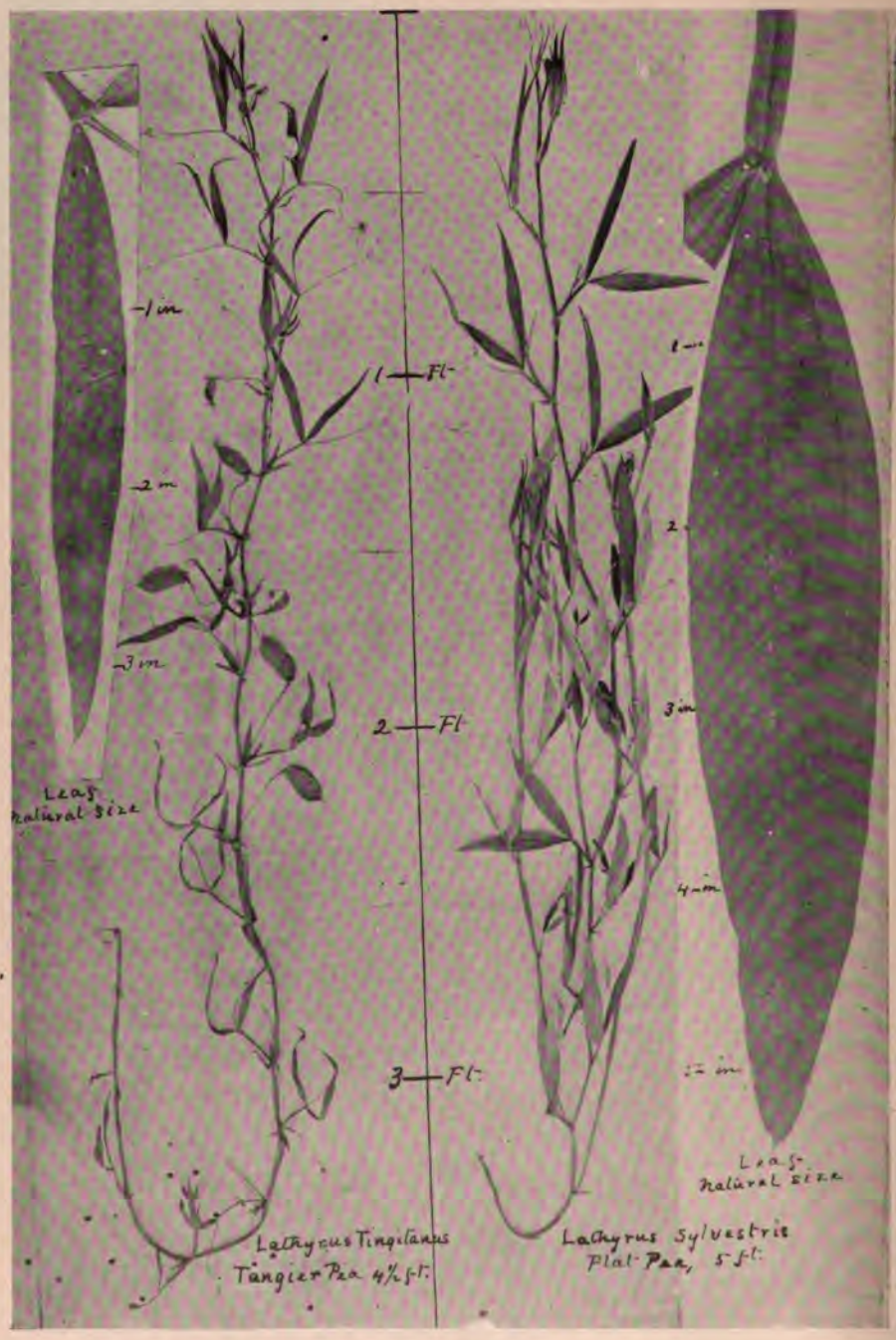
Name of Grain and Variety.	Date when Sown.	Date when Harvested.	Rate of Product per Acre.
Barley.			
Erfurt	Jan. 28	June 19	73 bushels.
Peacock	Jan. 28	June 19	73 bushels.
Annate	Jan. 28	June 16	60 bushels.
Imperial	Jan. 28	June 15	59 bushels.
Six-rowed Black	Jan. 28	June 20	58 bushels.
Himalay	Jan. 28	June 14	57 bushels.
Thuringian	Jan. 28	June 16	53 bushels.
Two-rowed	Jan. 28	June 14	53 bushels.
Six-rowed Brenner	Jan. 28	June 18	53 bushels.
Black two-rowed	Jan. 28	June 12	49 bushels.
Himalayan	Jan. 28	June 17	49 bushels.
Frick's Drought-Proof	Jan. 28	June 18	48 bushels.
Black Spring	Jan. 28	June 9	46 bushels.
White Australian	Jan. 28	June 17	44 bushels.
Chevalier	Jan. 28	June 16	44 bushels.
Palestine	Jan. 28	June 12	40 bushels.
Italian	Jan. 28	June 10	40 bushels.
Large Naked Two-rowed	Jan. 28	June 10	39 bushels.
Bluish	Jan. 28	June 15	37 bushels.
Sprat or rice	Jan. 28	June 18	37 bushels.
Four-rowed Spring	Jan. 28	June 18	37 bushels.
Berkeley Hybrid	Jan. 28	June 15	33 bushels.
Manchurian	Jan. 28	June 1	32 bushels.
Kalina	Jan. 28	June 1	30 bushels.
Nepaul	Jan. 28	June 10	27 bushels.
Oats.			
Heavy Winter	Jan. 25	July 29	43 bushels.
Polish	Jan. 25	July 30	41 bushels.
Surprise	Jan. 25	July 25	33 bushels.
Scotch Hopeton	Jan. 25	July 27	31 bushels.
Mox Rust-Proof	Jan. 25	July 27	26 bushels.
Thuringian	Jan. 25	July 25	23 bushels.
New Black Champion	Jan. 25	July 30	21 bushels.
Podolish	Jan. 25	July 27	15 bushels.
Canadian	Jan. 25	July 25	15 bushels.
Probsteier	Jan. 25	July 6	15 bushels.
White Bolognese	Jan. 25	July 27	12 bushels.
Harris Alabama	Jan. 25	July 25	11 bushels.
Brown Joanette	Jan. 25	July 29	6 bushels.
Large Naked	Jan. 25	July 6	6 bushels.
Gray Winter	Jan. 25	July 30	5 bushels.
Rye.			
Swedish Sand	Jan. 25	July 6	27 bushels.
Excelsior	Jan. 25	July 28	24 bushels.
Perennial	Jan. 25	July 25	23 bushels.
Hungarian	Jan. 25	July 28	23 bushels.
Spanish	Jan. 25	July 25	18 bushels.
St. John's Day	Jan. 25	July 25	7 bushels.
Saxon Perennial	Jan. 25	July 25	3 bushels.
Flax.			
Royal of Germany	March 20	June 10	931 pounds.
Russian	March 20	June 10	660 pounds.
White-flowering French	March 20	June 10	520 pounds.
Yellow-seeded	March 20	June 10	391 pounds.

MOX RUST-PROOF OATS: *J. C. Weybright, Kaweah, Tulare County.*—Mox Rust-Proof Oats grew to about thirty inches in height and headed nicely, on soil of granite formation. I think these oats would do well here if sown early on summer-fallow.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Mox Rust-Proof Oats grew well and yielded abundantly; fine plump grain.

C. Wine, Timberville, Ventura County.—The Mox Rust-Proof Oats was not sown until the 3d of March. It grew to a medium height and yielded well. It did not rust.

H. Brundage, El Montecito, Santa Barbara County.—The Mox Rust-Proof Oats rusted considerably, owing, I presume, to my proximity to the coast (about 2,000 feet elevation) and superabundance of fog the past season.



Two valuable FODDER PEAS distributed by the Central Station.

HEAVY WINTER OATS: *Henry Montoux, Williams, Colusa County.*—Heavy Winter Oats are not as good as the Mox Rust-Proof, which are as productive as the Surprise Oats.

W. A. Morris, Fouts Springs, Colusa County.—The Heavy Winter Oats did not look as though they would amount to anything until the middle of June, but they grew 4 and 5 feet tall, and I got 63 pounds from one pound of seed. I suppose I lost one fourth by birds. They are free from rust.

George B. Pearce, Jr., Paradise, Butte County.—Heavy Winter Oats made a good crop for hay, but I saved them for seed. They yielded well. They did not get ripe until about the middle of July, and although the weather was very dry, they filled well.

BERKELEY HYBRID BARLEY: *Raymond Plasse, Jackson, Amador County.*—I sowed the Berkeley Hybrid Barley on the 10th of February and harvested it on the 20th of June. I sowed it in good ground in rows one foot apart; it grew to about 4 feet to 4 feet 10 inches high, with good heads. I harvested 45 pounds to sow this year from the one pound of seed.

M. S. Curtis, Dunlap, Fresno County.—I think the Berkeley Hybrid Barley is the best barley for hay I ever saw.

Henry Montoux, Williams, Colusa County.—Berkeley Hybrid Barley seems to be well adapted to adobe soil; its growth is quite satisfactory, especially for hay, as it is quite leafy and beardless.

Geo. B. Pearce, Jr., Paradise, Butte County.—Berkeley Hybrid Barley sown on common red soil grew rather short. I think it requires rather rich land to grow a paying crop.

ST. JOHN'S DAY AND PERENNIAL RYE: *H. D. Rowe, Willits, Mendocino County.*—The St. John's Day Rye I received March last has done nicely. Also the Perennial Rye. They yielded 25 pounds to one of sowing, which I call well for this climate and sowing so late.

GRASSES AND FORAGE PLANTS.

THE FLAT PEA: *Lathyrus sylvestris.*—This plant was widely advertised abroad and in this country in the year 1891. It had been under trial for a number of years previously on the Continent and in Great Britain. The plant is a perennial legume, and is found growing wild in North European countries. The credit for noting its promise as a forage plant is given to Prof. W. Wagner, of Kirchheim, Teck, who collected seed of the wild species and improved the plant by cultivation for ten years. Similar work is credited to Dr. Stutzer, of Bonn. The seed from which the plants at this Station were grown was received in 1891 from the U. S. Department of Agriculture, and is believed to be the Wagner seed.

Plants grown from this seed and planted out late in 1891 rapidly extended themselves, and practically filled the soil of the plot with rambling rhizomes. The second season there was a dense mat of haulm or vine formed, which covered the ground and reached a length of about four feet. All through the dry summer months it maintained a bright green and grew continuously. The top growth was cut away in September and fed to animals, which ate it readily. The plant did not bloom, and the cutting was for the purpose of stimulating new shoots from the running roots, so that we might have plants for this year's distribution rather than wait another year for the seed. After the cutting, the new growth started rapidly. Our observation thus far indicates that the plant grows vigorously throughout the dry season, at least in the coast region. Its foreign reputation gives it a very permanent rooting and long service in the most arduous situations.

Analysis of the fodder made at this Station gives the plant very high nutritive value. This analysis, compared with those of other forage plants, may be found in another portion of this report. An engraving from a photograph of a specimen of this plant, also of another valuable fodder pea (*Lathyrus tingitanus*), grown at this Station, is given herewith. The following are extracts from correspondence:

H. E. Brown, St. Helena, Napa County.—Flat Pea roots all grew and are strong and green. I am very much pleased with it and believe it will be a valuable forage plant for us. It was planted on adobe and had no care whatever.

Robert Adler, Windsor, Sonoma County.—Flat Pea roots were planted at different points on my ranch and in various soils—chiefly clayey, and hilly land where the moisture was only that received from rain. While it was a severe test the result shows thrift. The roots have developed leaves and seem to be flourishing. I did not lose one plant, and the fact that we have had about 40 inches rain this season combined with white and black frost at different times shows this plant to be very hardy. If it can survive the drought of summer it will prove valuable.

G. S. Gilbert, Walker Valley, Mendocino County.—Flat Pea came up well and grew well. Animals broke fence and ate it close down and it has apparently died (but may come up).

L. Seiler, Shasta, Shasta County.—Flat Pea does first rate where the soil is reasonably moist and fertile. It has blossomed and borne seed abundantly.

I. A. Butchers, Pozo, San Luis Obispo County.—Flat Pea roots were planted on a rich sandy loam, damp enough for corn or potatoes. Some which was not irrigated grew but little, the runners 4 to 6 inches long; the irrigated plants grew better, but the weather seemed too hot. Chickens will eat it clean.

Wm. E. Whitmore, Whitmore, Shasta County.—I see nothing in the Flat Pea yet worthy of special commendation—being on new ground. I may say it did as well, perhaps, as alfalfa would have done with the same care.

F. S. Gould, Santa Barbara, Santa Barbara County.—Flat Pea in one situation grew very luxuriantly.

L. L. Guss, Brentwood, Contra Costa County.—Flat Pea on sandy soil made a fair growth and I think it will do well and will make good feed after it gets well rooted.

E. R. Pierson, Raymond, Madera County.—Flat Pea in our dry and hot location kept green all summer, but the heat was too great for it to do its best—the under leaves turned yellow and it stopped growing. The soil is granitic and a little irrigation was given.

Michael Gorman, San Ardo, Monterey County.—Flat Pea did fairly well, but hogs got at it in July and rooted it out and destroyed it all.

Dr. Edmund Goldmann, Wrights, Santa Clara County.—The Flat Pea plants made a fine growth, and I expect it will provide my pasture grounds with a new, valuable forage.

Mrs. J. L. Skinner, Wrights, Santa Clara County.—The Flat Pea roots all lived and grew all summer without watering; in the fall the hens keep it eaten down, but it continues to grow.

Geo. B. Pearce, Jr., Paradise, Butte County.—Flat Pea came up and grew nicely until about the middle of summer, when the tops died. I watered a few plants and kept them alive, but they grew only about a foot long without any cultivation.

W. C. Bradford, Arbuckle, Colusa County.—Flat Pea failed.

Crimson Clover: *Trifolium incarnatum.*—This strikingly handsome clover has been grown in our Garden of Economic Plants for many years. Although it made a very quick and luxuriant growth in winter, its disappearance early in the dry season condemned it as a dry land forage plant. If, however, the plant be estimated by its winter growth, it has valuable points, in localities suited to it, whether it be for early pasturage or more especially for producing a heavy crop while winter moisture is abundant, for plowing under as green manure in the early spring. During the last few years Crimson Clover has become very popular for such use in some of the Southern States, and there is abundant testimony of its value in refreshing orchard soils, for which it should be chiefly tested in this State. It is also worthy of note as a bee forage plant, and may serve the stock grower as well for winter feed, for it grows thriftily under temperatures which check the growth of alfalfa. The plant should not be confused with the common red clover of the East (*Trifolium pratense*), from which it is wholly distinct. It is clear, however, from the following reports, that the plant does not serve all California conditions:

John Jacob Schmidt, George, Clackamas County, Oregon.—Crimson Clover was sown in March; was in full bloom in June. I find it a worthy bee forage plant. A new crop grew from the seed which fell to the ground. During its bloom the bees liked it better than buckwheat close by. I got plenty of seed from it.

L. L. Guss, Brentwood, Contra Costa County.—Crimson Clover on sandy soil does not make a growth of over 4 inches in height. Sown with the first rains it does not bloom until April—too late to plow under for manure in orchards here. Alfalfa on same soil without irrigation makes two crops.

J. J. Veitinger, Jamul, San Diego County.—Crimson Clover came up well, but after dry weather it disappeared and by middle of May all was gone.

W. C. Bradford, Arbuckle, Colusa County.—Crimson Clover failed.

Geo. B. Pearce, Jr., Paradise, Butte County.—Crimson Clover was sown about the middle of February. Just as it came up, we had quite a freeze, which killed most of it. A few plants escaped and made a nice growth. I think if sown in early winter before severe frosts it would be a good plant for plowing under for a fertilizer.

Mrs. John Shaw Wright, Willits, Mendocino County.—Scarlet Clover came up all right, but the winters in this section are so wet—so much freezing and thawing, that the plants were killed completely out. Alsike Clover, sown at the same time, went the same way.

TEXAS BLUE GRASS: *Poa arachnifera.*—This grass is quite fully characterized in our Report of 1890, and its growth favorably commented upon. The following are later reports, and cover a wider area of the State:

H. H. Gird, Fallbrook, San Diego County.—Texas Blue Grass furnishes some feed in early winter, but is overgrown by the native annuals in the spring.

Wm. N. Runyon, Courtland, Sacramento County.—Texas Blue Grass has done well on bottom land without irrigation.

John Jacob Smith, George, Clackamas County, Oregon.—Texas Blue Grass is very fine on my high hill-land. It is green all the winter and through the dry summer. It stood the hot sun well. Cattle are very fond of it. I have planted a large place with it.

Harry E. Watson, Guerneville, Sonoma County.—Texas Blue Grass did not make any growth worthy of mention outside of a specially prepared place.

E. A. Jenks, Garberville, Humboldt County.—Texas Blue Grass roots on good corn land, east slope, did not grow very well. I think the climate does not favor it.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Texas Blue Grass roots grew and are doing well.

Geo. B. Pearce, Jr., Paradise, Butte County.—Texas Blue Grass did not do much last summer, although it had water occasionally. A few stalks ran up about a foot high and then bloomed. It has spread some and is growing nicely now. I think it would make a good pasture grass after it got started.

Miss M. D. Eshleman, Fresno, Fresno County.—The Texas Blue Grass grew well on sandy land (our disintegrated granite sand)—surface irrigation.

Edmund Goldmann, M.D., Wrights, Santa Clara County.—Texas Blue Grass has not proved hardy enough to withstand the drought, which is the more surprising to me since I have been for a number of years a resident of that State and therefore know the ardent sun and withering droughts of that part of the country.

C. C. Reynolds, Kelseyville, Lake County.—The Texas Blue Grass was planted in red soil (our soil is all red) and given about the same cultivation that alfalfa had by the side of it. The alfalfa died—the blue grass is now 3 feet high and looking well.

L. L. Guss, Brentwood, Contra Costa County.—Texas Blue Grass dried out; not deep rooted enough for this soil. Another clover, called Spike Clover, is better suited for the sand; it makes a strong growth of about 3 feet and stands up well; is good feed while young.

S. I. Darling, Fruitvale, Alameda County.—The Texas Blue Grass is on light gravelly soil of a southern slope of the hills above Fruitvale, and has not been irrigated. It remained unscorched through the summer, and each single root has increased to the size of the whole package received, in spite of being cropped once by a cow that spied out its tempting greenness. Texas Blue Grass is a success.

Geo. A. Raymond, Miramonte, Kern County.—I notice that the Texas Blue Grass grows more or less right through these long dry spells where an alfalfa field is brown.

G. Lotman, Merced, Merced County.—The Texas Blue Grass did very well upon a hilly place, and has grown almost without any water. I have now one hundred times as many roots as I received.

Theo. G. Ed. Wolleb, Fruitvale, Alameda County.—The Texas Blue Grass roots were planted on poor, dry soil, and have not grown much; they are alive—that's all. Australian Rye Grass alongside did well.

H. Brundage, El Montecito, Santa Barbara County.—The Texas Blue Grass was only watered in the early part of the season, or until the certainty of the growth was assured, when I simply watched it during the dry season, which it weathered in good shape, stooling out plentifully. I think it will prove a desirable grass in this section. My ground is a sandy loam with gravel and bowlders underlying.

Sol. Beckom, Cahto, Mendocino County.—The Texas Blue Grass you sent me in March has done well, considering that the place where I planted it was shaded about half the day. When I set the roots out there were 13 in all, and in November I counted 64. I gave the plants one good irrigation in August; at that time they showed no sign of drought. It was on rocky clay land.

Robert Hastie, Clayton, Contra Costa County.—Texas Blue Grass is a failure.

ELLIOTT'S SIDA: *Sida Elliotti.*—This malvaceous herb is indigenous in the Southern States, and was sent to us for trial by Hon. G. D. Tillman, of South Carolina, whose experience with the plant is given on page 175 of our Report for 1892. Observation of its growth in Berkeley, which is also described in that report, led us to approve it for wider

trial in waste places for a browsing plant, not for cultivated lands. It evidently does not succeed very widely, and yet under proper conditions may prove of considerable value. This is shown by the following notes from correspondence:

H. H. Gird, Fallbrook, San Diego County.—Elliott's Sida, on hillside granitic soil, came up in the spring (after the weather became warm) thickly. Rabbits, rats, and squirrels fed upon it continuously. It is green at this writing (December); average height, 8 inches; very bushy and full of seeds. It surely is hardy and must be good feed.

L. L. Guss, Brentwood, Contra Costa County.—Elliott's Sida, planted on sandy soil, made a good growth of a woody texture—too hard and tough for good pasture except for sheep and goats.

E. R. Pierson, Raymond, Madera County.—I planted Elliott's Sida in my garden and obtained a few plants which made a fair growth and matured a quantity of seed. Our extreme heat here in summer (110° or 112° in the shade) did not appear to affect the plant unfavorably, as it does almost everything. It was slightly irrigated; remained green throughout the summer and showed no signs of wilting.

Robert Hastie, Clayton, Contra Costa County.—Elliott's Sida was a complete failure. I transplanted some of 1892 plants on corn land. They grew well at first, but made no crop, and died in August.

L. Seiler, Shasta, Shasta County.—Elliott's Sida did not germinate, although planted at different times.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Elliott's Sida grew only about half a foot in height, and is still green (in January), having produced a quantity of seed. So far it has not been affected by the frost.

Solomon Agerter, Santa Cruz, Santa Cruz County.—Elliott's Sida I planted on upland; came up finely, but the birds took it up by the roots.

Henry Murphy, Milo, Tulare County.—Elliott's Sida seed was sown in March and April; but few seed came up. They made slow growth, being about 6 inches high. They were affected by the frost in December.

ESPARCETTE OR SAINFOIN: *Onobrychis sativa.*—This clover was urged quite loudly upon the public in the agricultural journals about four years ago. It was claimed that it would thrive on soils too dry for alfalfa. Our experience with the plant at this Station, for a decade or more, did not approve this claim, but we met the popular demand by offering the seed for general trial. Our Report for 1890 shows that the plant was, on the whole, a disappointment. The following notes from later correspondence tend in the same direction. They will be useful for future reference:

C. C. Reynolds, Kelseyville, Lake County.—Esparcette does well.

Geo. B. Pearce, Jr., Paradise, Butte County.—Esparcette or Sainfoin makes a better first crop than alfalfa, though the after-growth is not so good; however, I think it will stand more dry weather.

Edward C. Coburn, Middletown, Lake County.—Only a few plants or seeds of Sainfoin grew, but they seem to withstand drought well.

Robert Hastie, Clayton, Contra Costa County.—Esparcette or Sainfoin is doing fairly.

Mrs. J. D. McDonald, Burnt Ranch, Trinity County.—The Sainfoin did not do very well. I planted it on a very dry hillside where no stock could bother it; some was just scattered on the ground and the remainder sown on cultivated land, but it did poorly in both places.

Geo. B. Pearce, Jr., Paradise, Butte County.—Esparcette or Sainfoin made a good stand. Some that had the overflow from irrigating the orchard grew about a foot high and then went to seed; seemed rather inclined to spread out on the ground; some of it that did not get any water lived through, but did not grow much. It was sown on sidehill facing northwest; rather poor soil.

Geo. A. Raymond, Miramonte, Kern County.—I have tried for two seasons to get Esparcette started, but it seems almost impossible to succeed. What few have started seem to do well, but in spite of the assertion that it does best on a moderately dry soil, mine does best where near plenty of water—even on the inside of ditch-banks at the water-line and where the water is continually running. In fact, such are the only places where it has started.

L. L. Guss, Brentwood, Contra Costa County.—The Esparcette received two years ago is not suited for this soil (drift sand). It smothers and does not make a strong growth.

TALL OAT GRASS: *Arrhenatherum avenaceum.*—This grass must be considered one of the most promising of those so far proposed for arid conditions. This fact is shown by the account given of it in our Report

for 1890. Since then we have continued the distribution of the seed, and later reports are as a rule confirmatory of the usefulness of the plant. We give the following:

Mrs. Theresa C. Keys, Alhambra, Los Angeles County.—Tall Oat Grass seed was sown in March and has been irrigated a number of times. It is growing and looking well but is far from tall. Our season has been so dry and cool that none of the plants or flowers have made the growth as usual. Flowers have gone to blossoming when only half their usual height, and presume this is the cause of the lack of height in the Oat Grass.

Robert Hastie, Clayton, Contra Costa County.—Tall Oat Grass did finely. From the old roots it yielded at the rate of three tons to the acre. It had no cultivation nor irrigation.

Edward C. Coburn, Middletown, Lake County.—Tall Oat Grass is valuable when once started.

H. H. Gird, Fallbrook, San Diego County.—The Oat Grass does well on damp land.

Mrs. Thos. Anderson, Olinda, Shasta County.—Tall Oat Grass proves to be, I think, a very valuable grass for pastures, as it is green all through the summer and has had no water; I think it will prove valuable for dry land. It grows like bunch grass with a turf and is always green and sweet. Stock are very fond of it. The seeds drop from the head, while the base of the plant is still green. It starts early and stays green all through the summer and fall.

OTHER FORAGE PLANTS.—The following brief extracts from correspondence relate to plants which have been fully discussed in earlier reports, and information concerning them can be supplied on application:

HUNGARIAN BROME GRASS: *Bromus inermis.—G. S. Gilbert, Walker Valley, Mendocino County.*—Brome Grass does remarkably well. Stood the drought of the summer well and is now thick and bunchy. Animals like it.

L. Seiler, Shasta, Shasta County.—Hungarian Brome Grass does well on reasonably fertile soil. I have some four years old, which comes from the root new every year. It keeps green longer than any other grass and sprouts again as soon as it gets a little moisture. I do not irrigate it.

E. A. Brinkerhoff, Forest Ranch, Butte County.—The Hungarian Brome Grass survived the severe drought of the past summer, but only grew 2 or 3 inches high and has remained green. In good soil I think it would do well.

JAPANESE WHEAT GRASS: *Agropyrum Japonicum.—H. H. Gird, Fallbrook, San Diego County.*—The Japanese Wheat Grass is a very lusty grower; good feed, and extends itself freely, but not quite equal to *Milium multiflorum* on dry ground.

Robert Palmer, Havilah, Kern County.—I am very much pleased with the Japanese Wheat Grass. I sowed it in February, and after I gathered the ripe seed in July; it made a rapid growth in large tufts. It is now quite green (January), in spite of many heavy frosts, and is over a foot high. It promises to be an excellent winter feed in the mountains.

JOHNSON GRASS: *Sorghum Halapense.—Eugene Melvin, Paradise, Butte County.*—I have a plot where the lava rock is barely covered with from a few inches to a foot and a half of dry, rocky soil, which I planted with Johnson Grass roots. It makes very good summer pasture; it is neceesary, however, to plow the land late every spring, as it bakes after the heavy rains. I am well pleased with it for that kind of soil, and shall continue planting all that kind of soil I have to it, but I do not like to plant it on good soil on account of its tendency to spread.

Wm. H. Mullen, Big Bend, Butte County.—I never have had anything that would grow well on dry land but Johnson Grass, and that I wish I never had tried. Stock do not like it for hay, but will eat it when young and green.

SNAIL CLOVER: *Medicago turbinata.—Robert Hastie, Clayton, Contra Costa County.*—Snail Clover did well till it dried up; then the rabbits took all of it, and they made it go as far as possible, for they commenced at the outer points and ate it down gradually to the roots.

Jos. Geschwend, Sur, Monterey County.—The Snail Clover in a dry sandy soil made a growth of from 2 to 4 feet and matted all over the ground. The hay was at once fed to cows, and they liked it very much.

E. R. Pierson, Raymond, Fresno County.—I sowed the Snail Clover in a light sandy soil on a dry hillside, where it grew from 8 to 12 inches high. It starts earlier and remains green longer than any of the native clovers growing in a similar location.

TAGASASTE: *Cytisus proliferus albus.—H. H. Gird, Fallbrook, San Diego County.*—Tagasaste failed to come up the first year, but the next fall came up thickly early in the season, and all died in January—probably from too much moisture.

Mrs. E. M. Edwards, Olinda, Shasta County.—Tagasaste planted in August is growing finely, and is about 2 feet now (January 26th).

N. S. Adams, Raymond, Madera County.—Tagasaste seed is very hard to start; some will stand in water for days without any visible change, but I find if the least particle of shell is removed they will swell as quickly as wheat, and will germinate readily without previous soaking.

TEOSINTE: *Reana luxurians.—W. M. Bristol, Mezzina, San Bernardino County.*—On April 28th I planted a small plot of Teosinte on dry upland soil of good quality. It received no irrigation until October 1st; was benefited some, however, by a heavy shower in August. When thoroughly watered it made a vigorous growth, some reaching a height of 10 feet. As a forage plant I believe it will prove of great value for the hot interior valleys where water for irrigation is abundant. It has the appearance and taste of corn fodder, but is sweeter.

JERUSALEM ARTICHOKES: *Helianthus tuberosus.—Mrs. Emily Brown, Kelseyville, Lake County.*—Brazilian Artichokes planted two years ago on gravelly soil and irrigated have multiplied well. The ground is alive with them wherever I dig in the vicinity of the first planting. One year ago I took up a start and planted in a more favorable spot of ground, twelve hills, and they made large hills of artichokes. I did not measure but I think there were fully one half bushel in bulk in the twelve hills. I think they exceed the yield of anything else on the same ground. I pare them and cook as salsify and they also make nice soup. I cook them for my chickens. They also make pickles.

Chas. Gloeckner, Healdsburg, Sonoma County.—The Artichokes turned out well. Out of about one dozen plants I got about a sackful. They make fine feed.

David Richardson, Santa Paula, Ventura County.—The Artichokes came up and grew, but lacking enough moisture failed to mature.

M. Gorman, San Ardo, Monterey County.—White Artichokes grew very well, but the Red Brazilian seem better than the white.

Henry Montoux, Williams, Colusa County.—Jerusalem Artichokes planted about the 15th of March yielded from six to eight large tubers to the hill. My milch cows and pigs seem to relish them.

E. A. Brinkerhoff, Forest Ranch, Butte County.—Jerusalem Artichokes have done the best of anything I have tried in a poor dry soil. The package I got from you yielded 40 pounds. The white produced twice as much as the red. Neither had any water and were on a sidehill in a clay loam.

Solomon Agerter, Santa Cruz, Santa Cruz County.—The Red Artichokes did not do as well as the white, in moist ground, but the white yielded beyond expectation, producing 20 pounds and over to the single eye, and the cattle eat them with a relish.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—The Jerusalem Artichoke (White French and Red Brazilian), of which I received five bulbs of each, all grew splendidly, and to the height of 6 feet. The White French produced a large burlap sack of bulbs. The Brazilian would have done equally as well, only the gophers got at them, consuming over half before discovered.

E. A. Jenks, Garberville, Humboldt County.—I have planted Jerusalem Artichokes and raised large crops, but hogs will not eat them raw. I have to cook them and put wheat with them or my hogs will not eat them.

JERSEY KALE.—*J. Hardin, Pope Valley, Napa County.*—Jersey Kale, on rather dry ground, did not do very well.

Robert Hastie, Clayton, Contra Costa County.—Jersey Kale did very poorly. Land too dry.

Solomon Agerter, Santa Cruz, Santa Cruz County.—Jersey Kale yields bountifully. The cattle eat it with a relish; also in its early stages it makes excellent greens for table use. I have some now growing that have attained a height of 5 feet.

W. A. Morris, Fouts Springs, Colusa County.—Jersey Kale grew 4 and 5 feet tall, with very broad leaves. Good for cattle.

Mrs. James Enright, Santa Cruz, Santa Cruz County.—Jersey Kale grew tall and strong, producing a great amount of feed. It was often cut down, but always came up strong and thrifty.

Jos. Geschwend, Sur, Monterey County.—Jersey Kale is a famous plant, growing here under any fair treatment 6 feet; and such an amount of fodder that a man would not want to pack more than three stalks. I think 6 feet apart for the plants would be better than 4, as I have them.

TREES AND SHRUBS.

Supplementary to reports in earlier publications of the Station, the following notes are selected from our correspondence:

ENGLISH OAK: *Quercus robur.—C. Brower, Bakersfield, Kern County.*—The English Oaks manifested a surprising vitality, though this may have been partially on account of their longer roots and stouter stems—and in spite of the glowing heat upon the surrounding sand, as well as their denudation of foliage by rabbits which had found their way within the inclosure, they survived the summer and made fair growth. This was a surprise to me, as I planted them with grave doubts of their ability to withstand the heat and dryness of our atmosphere, but I now regard them as well adapted to our climate.

BLACK WATTLE: *Acacia decurrens.—Mrs. Almeda Frakes, Del Sur, Los Angeles County.*—Black Wattle trees came up and grew finely. I have over a hundred trees from the package of seed, some about 15 inches high.

Abner L. Butterfield, Escondido, San Diego County.—I have one Black Wattle tree, which I raised from seed I received from the Station five years ago, that is 11 inches in diameter at the ground and between 30 and 40 feet high.

E. R. Pierson, Raymond, Fresno County.—The Black Wattle seems best suited to this locality as far as can be judged from a single season. It stands excessive heat and dryness, and quite severe frosts.

CAROB: *Ceratonia siliqua.—Abner L. Butterfield, Escondido, San Diego County.*—I have one Carob tree that I raised from seed that a missionary brought from the East. It bore a few pods with full-grown seed this summer. It is in blossom now (December), and has been for a month. There are quite a lot of little pods on it now. Some of the blossoms appear to be perfect, and some staminate only. There is no other tree of the kind anywhere near here. There are none within several miles.

KAI APPLES: *Aberia Kaffra.—Jos. Burtscher, Auburn, Placer County.*—Kai Apples are doing very well.

J. C. Harvey, Los Angeles, Los Angeles County.—Kai Apples are flourishing with me, and doubtless will bear fruit in this section.

J. Wallace F. Diss, Redlands, San Bernardino County.—One of the Kai Apple plants was given the best of care; the other scarcely any, only receiving water twice during the year. The latter did every bit as well as the one well cared for, and both have put forth a strong, vigorous growth, showing themselves well adapted to this climate.

E. R. Pierson, Raymond, Fresno County.—The Kai Apples stand our very hot weather better than the cold. Mine were injured by frost, though they were covered with sacks. They need to be well strawed, or given some secure protection against freezing weather.

CAPERS: *Capparis spinosa.—J. Wallace F. Diss, Redlands, San Bernardino County.*—The Capers have not done well, and it is my impression that they would do better in a damper atmosphere.

W. R. H. Weldon, Ventura, Ventura County.—The Caper plants grow nicely, giving an abundant supply of blossoms from May 15th until frost comes, when they are killed down to the ground. I do not think that they would be a commercial success here.

COFFEE: *Coffea arabica.—Jacob Miller, Colegrove, Los Angeles County.*—I have a Coffee tree in full bearing, ten years old.

VEGETABLES.

NEW ZEALAND SPINACH: *Tetragonia expansa.*—Described by Von Mueller as a good culinary herb and as useful for restraining drifting sands; growing even during severest heat and drought. Our correspondents speak of it also in the highest terms as a table vegetable.

T. Phillips, Simi, Ventura County.—New Zealand Spinach does finely and seems to be at home.

Mrs. L. Weitz, Farmington, San Joaquin County.—New Zealand Spinach was sown on the 16th of March, and on the 20th the big flood came over it, but did not hurt it. It grew all summer, until late in November the frost killed it. Some of it was 7 or 8 feet long. It was well watered and in very rich ground.

S. C. Dondore, Lakeside, San Diego County.—The New Zealand Spinach I received last year is growing nicely, without irrigation, and I consider it an excellent article for table use.

Geo. Jordan, Colfax, Placer County.—New Zealand Spinach proved a great success in every respect.

J. Hardin, Pope Valley, Napa County.—New Zealand Spinach got a very late start, but kept growing till frost.

Robert Hastie, Clayton, Contra Costa County.—New Zealand Spinach is the "boss" vegetable. It grows all summer on very dry land. It is a beautiful dark-green to-day (November 18th). It is worth a place in the flower garden where water is scarce, and for the table it has no superior—to my taste. It stands very little frost, but the growth came up from the old roots and did well after being frozen down. The top growth seems as easily killed by frost as the tomato. I have had it in good cutting order in January, but not quite so much of it is fit for use as in spring, on account of it being rather stringy.

S. F. Thorn, Glenwood, Santa Cruz County.—The New Zealand Spinach has made a wonderful growth, running over 5 to 6 feet, though we are constantly cutting and eating it. Boiled with bacon, pork, or a piece of ham, it is the most agreeable vegetable for greens that we have thus far found.

MELDE'S PERENNIAL BEAN.—A handsome, large, white bean, with a perennial root, from which climbing runners start each year. The seed was donated by Mr. Henry Melde, of Humboldt County.

J. Harper, Sonoma, Sonoma County.—Melde's Beans grew very well and flowered all summer.

Mrs. L. Weitz, Farmington, San Joaquin County.—Melde's Beans would have done very well, but the bugs kept the blossoms all eaten off until after July; after that time I got about 5 pounds of green beans from four vines.

Mrs. Geo. F. Reid, Nita, Lake County.—We planted the bean in a rich, black soil. The chickens got at it and ate all the flowers and leaves off; then I fenced it in and it bloomed again and think that I would have had more beans but the humming-birds broke the flowers off before they should have fallen. I will plant the beans that I have saved, for I think they are very nice.

CEYLON PEA.—This variety of table peas was received by us from Ceylon; its true varietal name not being known to us. It has proved a very productive and desirable late pea.

Dr. Edmund Goldmann, Wrights, Santa Clara County.—Ceylon Peas came up splendidly and yielded such an excellent crop last summer that they now have superseded all other kinds in my vegetable garden. We are having some of them to-day (December 31st) on our dinner table, and it is not unlikely we shall have them all winter.

Robert Hastie, Clayton, Contra Costa County.—Ceylon Peas sown January 22d made a first-rate crop of excellent quality.

A. B. Burdick, Kaweah, Tulare County.—Ceylon Peas prove to be a good grower. The yield was heavy and large; full pods of a fine quality of peas. With me it is as good as the best.

Abner L. Butterfield, Escondido, San Diego County.—The Ceylon Pea is very nice and yielded the best of any kind I have ever tried here.

H. H. Ward, Escondido, San Diego County.—Ceylon Peas did not grow nor yield as well as other varieties that were alongside of it.

Minnie Neligan, Creston, San Luis Obispo County.—The Ceylon Pea grew splendidly. I never saw such large pods as it bore.

ECLIPSE AND OSBORN BEETS.—Early red table beets:

Geo. A. Raymond, Miramonte, Kern County.—The Eclipse and Osborn Beets started easily and made good growth with irrigation. Beets were of fair size and remarkably tender and sweet.

MISCELLANEOUS.

TOBACCO: *Ragland's Conqueror.—B. F. Roberts, Mossy Glen Ranch, Leighton, Shasta County.*—The plants which I grew from Ragland's Conqueror tobacco seed were set during the first week in May on ground from which a crop of lettuce had been taken. The soil is loose and sandy, and had received no fertilizer save a moderate coat of stable manure, not thoroughly decomposed, early in the spring. The plants were shaded for a day or two, and about two weeks subsequently received one irrigation and a day or two later a hoeing. No further attention was given save topping and sprouting. The first crop was ripe by July 15th, but was not cut until a month later. The ten leaves to a stalk averaged 30 inches long by 12 inches wide, and have made a most excellent quality of smoking tobacco without any doctoring. After cutting, one shoot from each stalk was allowed to grow, and a second crop matured and was cut November 15th—of very fair quality. The stumps are still alive and will produce other crops next year. My tobacco has been tested and examined by several persons—some of them experienced tobacco-raisers from the East—and all unite in pronouncing mine of a superior quality.

Yellow Oronoko.—L. Wilkinson, Middletown, Lake County.—The Yellow Oronoko tobacco seed I gave a fair trial, and I find it the best I have seen raised on the Pacific Coast. I have full confidence that I can make tobacco a success in California.

GOPHER PLANT: *Euphorbia lathyris.—Edmund Goldmann, Wrights, Santa Clara County.*—I had the Gopher Plant seed sown close by some carrots which gophers were destroying, yet the animal captured the carrots just the same. My opinion of the plant, to keep gophers away, can scarcely be a very exalted one.

Robert Hastie, Clayton, Contra Costa County.—The Gopher Plant is a humbug. I have grown it along my garden fence for twenty years and the gopher runs under and round it all the time.

E. A. Jenks, Garberville, Humboldt County.—I have the Gopher Plant growing in my orchard, but gophers live there also.

LIST OF DONATIONS

Made to the Experiment Stations Since December, 1892, with Brief Notes on Some Results.

In the following acknowledgment of gifts of seeds and plants that the Agricultural Department of the University has received since our last report, lack of space prevents us from making a complete and itemized catalogue. We desire, however, to express our thanks to all our correspondents in this department of the Station work, and assure them that their continued interest will be cordially appreciated.

The system adopted by the Stations respecting donations of seeds, scions, cuttings, bulbs, plants, and trees is extremely simple. We are always glad to receive samples of new or rare varieties or species, and give them all possible care at the Central Station, or at the sub-stations, as seems best under the circumstances. We register everything as soon as received, and do not distribute nor propagate (except for experimental purposes) without the permission of the person sending us the stock. We do not sell stock under any circumstances. The interest of the Station workers in new plants is wholly scientific, and not commercial.

Persons sending seedling fruits for testing, however, should remember that we desire only varieties of real promise, and always with notes, as far as possible, upon the origin and history of the seedling. We cannot test large and miscellaneous lots of wholly untried seedlings. The originators must bring them into bearing, and compare the results with standard varieties to the best of their ability.

We always have large orchard trees to work over, besides small nursery stock, and can receive scions or buds of new varieties in the season, and top-work immediately. Correspondence from fruit-growers, nurserymen, and amateur hybridizers is always welcome.

Exchanges on the part of the Station include everything in our collection, subject only to the limitations imposed by the originators, or the proprietors, of varieties not yet introduced, and to the general principle that the Station must not incur any financial loss in such exchanges. As with seeds, special distributions of scions will be made, at times. The Station particularly desires the coöperation of progressive horticulturists in the work of securing as large a representation as possible of Pacific Coast seedling fruits of every class and species.

PLANTS AND TREES.

From Superintendent John McLaren, of Golden Gate Park, San Francisco, Cal.:—Five hundred and seventy trees for planting on the top of Mount Hamilton, around the Lick Observatory. This fine collection included six species of Acacias, two of Cypress, and seventeen of Pine; also Ericas, Ulexes, and Genistas for ornamental work. Among the pines were P. massoniana, P. sylvestris, P. nigra Austriaca, P. Laricio, P. mitis, P. Torreyana, P. sabiniana, P. insignis, P. maritima, P. pinea, P. Coulteri, P. monticola, and P. halepensis.

From Mr. Brakefield, of Hall Valley, on the Mount Hamilton road, east of San José, Santa Clara County, California:—Scions of a seedling apple of promise.

From S. L. Watkins, Grizzly Flats, California:—Plants of fifteen varieties of strawberries, including the following: Hood River, Great Pacific, Stonebreaker, Sierra Red Alpine, Graham, Montreuil, Saunders, Wolverton, Lady, Carolina Superba, Early Dawn, Western Prolific, Far West, Gillespie, and Dollar. This collection was sent to the Southern California sub-station, in the Chino Valley, where the foreman is paying particular attention to small fruits.

From J. Coppin, Loomis, Placer County, California:—Trees of a seedling almond, with samples of the nuts. A large hard-shell of very fine appearance for the type.

From Alexander & Hammon, Biggs, Butte County, California:—Trees of the following sorts: Blue Pearmain and Winter Banana apples; California Red plum; Sneed, Japan Blood, Brooks' Butte, and Buck's Prolific peaches; Spark's Mammoth apricot; Olmstead nectarine. Several of these, such as Brooks' Butte peach, are new and unusually promising California seedlings not yet widely known, but deserving the attention of horticulturists.

From Frank Owen, Monticello, California:—Scions of a new seedling apricot raised by him, and popular in his district.

From E. B. Silva, Newcastle, Placer County, California:—Plants of Tippecanoe and Dollar strawberries. The Station is indebted to Mr. Silva for stock of new fruit on several occasions.

From Father Agapius Honcharenko, Ukraina, Alameda County, California:—Cuttings of an olive from Mount Lebanon, also of a grape from the same region. Both are from the famous monastery gardens. The grape has been propagated for the sub-stations under the name of Honcharenko.

From J. C. Shinn, Niles, California:—Trees and plants of the following species for the sub-stations: Quercus suber, Dracæna indivisa, Sabal palmetto, Chamærops excelsa, Phœnix dactylifera, Mahonia Aquifolium, Syringa vulgaris; also 300 bulbs of Amaryllis, Narcissi, and Gladioli for the sub-station gardens; also trees of English and of Persian walnuts, and of Hatch Seedling No. 2 almond.

From W. J. McLean, Julian, California:—Scions of six varieties of apples and one of peach, chiefly new California seedlings of more than ordinary merit.

From R. C. Kells, Yuba City, California:—Scions of Bishop grape, a noted California seedling.

From W. King, Arroyo Grande, California:—Five trees of a seedling apricot.

From C. F. Loop & Sons, Pomona, California:—Seventeen varieties of olives.

From J. S. Calkins, Pomona, California:—Fourteen varieties of olives.

From Alfred Wright, Pomona, California:—Eight varieties of olives, one Yucca, and one Erythræa edulis.

From Leonard Coates, Napa, California:—Trees of Weedsport prune, a new variety here.

From Mr. Meserve, Pomona, California:—Ten ornamental plants and one Phœnix canariensis.

From Mrs. A. Skinner, Pomona, California:—Cuttings of twenty-two named varieties of roses; also water hyacinths for aquatic garden.

From John Gamble, Haywards, California:—Roots of a jointed grass (*Poa stolonifera*), brought by him from Ireland.

From J. V. Cotta, Carroll County, Illinois:—Scions of ten varieties of apples, all new to this coast, and several not yet in commerce.

From Joseph Hart, Fayetteville, Arkansas:—Vines of a new seedling grape.

From Prof. W. H. Massey, North Carolina Experiment Station, Raleigh:—Cuttings of several new figs, sent to the Tulare sub-station.

From Prof. E. R. Lake, Experiment Station, Pullman, Washington:—Scions of six new apples and one new plum. Several of these are as yet unknown in California.

From Harrison, Storrs & Co., Painesville, Ohio:—One tree of Harris apricot, and several greenhouse plants.

From S. R. Kramer, Kingston, Ohio:—One vine of Uller's Mammoth grape, originating in Ohio, about 1885.

From T. V. Sluman, Mount Tabor, Oregon:—Trees of Pacific prune, a large blue prune highly praised in the Northwest, where it originated.

From George Ruedy, Colfax, Washington:—Trees and scions of Palouse apple, Moore's Arctic plum, Stewart Ironclad peach, a new seedling pear (not named), and a new seedling prune. The Palouse apple has been much praised as a market fruit, but is not yet known in California.

From Seth Lewelling, Milwaukee, Oregon:—Trees of Bing cherry, an Oregon seedling introduced by him, and of great local reputation.

From P. J. Berckmans, Augusta, Georgia:—A very fine collection of Southern fruits, embracing eighteen varieties of apples, two of apricots, two of figs, twelve of peaches, two of nectarines, one of mulberry, seven of pears, and five of plums. All of these are new to California growers, as far as known, and the list includes some very promising fruits for the warmer parts of the State. As with other new fruits now at the Station, the full description must wait till a complete catalogue can be prepared.

From J. H. Hale, South Clastonbury, Connecticut:—Trees of Crosby peach.

From O. M. Goodrich, Fellowship, Florida:—Fifty seedling American persimmons from selected seed. These have been distributed to sub-stations, and partly used for stock.

From W. F. Heikes, Huntsville, Alabama:—Trees of five new varieties of Southern peaches; also of one new plum, one new pear, one new cherry, and three new apricots. Like the collection from Mr. Berckmans, this is a typical and interesting collection from a very reliable source.

From C. E. Pennock, Fort Collins, Colorado:—Ten plants of the Improved Dwarf Rocky Mountain cherry. These were distributed to the sub-stations, and planted at the Central Station. They bloomed the first week of April, 1894. Mr. Pennock also sent cuttings of a New Rocky Mountain willow.

From Walling & Jarisch, Oswego, Oregon:—Stock of a number of new and standard varieties of fruit, including the following: Red Romanite and Virginia Greening apples, Russian apricot, Champion prune, Bing cherry, Early Charlotte peach, White Grape and Black Naples currants, Souhegan raspberry, and Oregon Everbearing strawberry. Trees and plants were received at two different times from this firm.

From McGill & McDonald, Salem, Oregon:—Trees of Tennant prune, an Oregon seedling of promise.

From H. A. Corliss, St. Helena, Oregon:—Plants of two varieties of seedling gooseberries, of high local reputation.

From E. P. Smith, Gresham, Oregon:—Trees of Oregon peach (in dormant bud); scions of Blaine apple. Both are new seedlings of the Northwest, of local reputation.

From E. M. Beuchly, of Greenville, Ohio:—Scions of Downing's Winter Maiden Blush apple. Mr. Beuchly had previously sent plants of his noted El Dorado blackberry and Greenville strawberry.

From J. T. Lovett, Little Silver, New Jersey:—Scions of Lincoln Coreless pear, of Lincoln plum, and of Fuller quince.

From Prof. Charles S. Sargent, Arnold Arboretum, Cambridge, Massachusetts:—Trees of Asiatic oaks for the Forestry Stations. A fine collection, representing five species, and several varieties, all rare and very important for our growing arboretums at Chico and Santa Monica.

From Prof. L. H. Bailey, Cornell University, Ithaca, New York:—Scions of twenty-one varieties of American plums.

From A. W. Thornton, Whatcom County, Washington:—Cuttings of new gooseberries.

From Superintendent Thomas Sharpe, Government Experiment Station, Agassiz, British Columbia:—Scions of forty-seven varieties of apples and pears, mostly new to this region. Some of these varieties are very old English and French sorts; others represent very recent introductions from England, and one or two are Canada seedlings. A very interesting collection.

SEEDS.

From Gustav Briere, Los Angeles, California:—Seeds of Cytisus laburnum, for the Forestry Station.

From Sunset Company, San Francisco, California:—Seeds of thirty-seven named varieties of sweet peas.

From Mrs. J. D. McDonald, Burnt Ranch, Trinity County, California:—Seeds of a native grass. Mrs. McDonald writes that it "grows on heavy clay soil, keeping green the year round. When the soil is so dry that it is almost impossible to drive a pick into it, and is cracked open, the grass will be green and thrifty." Cattle and horses are said to be very fond of it. The normal height of the grass is about ten inches.

From F. P. Hosp, Redlands, California:—Seeds of a plant called "Poselle," from Siam, said to be a valuable fruit-bearing annual.

From W. A. Lawson, Los Angeles, California:—Seeds of South African Mimosas, Proteas, and other species, in all nine, seven of which are probably new to this region.

From D. M. Dimmick, Santa Barbara, California:—Seeds of the new cow-pea "Wonderful."

From H. C. Cone, Thermal, Fresno County, California:—Seeds of a native grass said to grow on the driest soil, remain green, and furnish excellent pasturage. Height of grass, 26 to 39 inches.

From Hon. Horace Davis, San Francisco, California:—Package of a new wheat produced in the Mokelumne River region.

From W. J. Strachan, Foreman Forestry Station, Santa Monica, California:—A collection of seeds from Hawaiian Islands; also coffee beans, gathered by Mr. Marcuse in Mexico; also seeds collected in Santa Monica.

From W. H. Maule, seedsman, Philadelphia, Pennsylvania:—Seeds of the "Wonderful Sugar Melon," and of Begonia Vernon.

From W. Atlee Burbee, seedsman, Philadelphia, Pennsylvania:—Thirty-five packets of vegetable and flower seeds for trial in the grounds. Some of these are new and not yet sent out to the general trade. Distributed to the sub-stations.

From Northup, Braslan, Goodwin & Co., seedsmen, Minneapolis, Minnesota:—Twenty-one packets of vegetable and flower seeds for trial. Distributed in smaller packages to sub-stations.

From the Iowa Seed Co., Des Moines, Iowa:—One package of Gold Mine corn.

From Peter Henderson & Co., seedsmen, New York:—Five packages of new varieties of seed, sent out for trial.

From Professor Thomas Meehan of Philadelphia, Pennsylvania:—Seeds of Lawsonia alba, the famous Henna plant of the Orient.

From Chauncey M. St. John:—Seeds of the White Ebony tree.

From A. B. Jones, Hartford, South Dakota:—New hybrid barley "Success."

From Delano Moore, Presque Isle, Maine:—Seeds of Pomroy bean, Carsley cucumber, and Alexander tomato.

From the Louisiana Experiment Station, Baton Rouge, Louisiana:—Twenty-three varieties of sweet potatoes—a fine named collection, elsewhere reported upon more in detail.

From the Agricultural Department, Washington, D. C.:—Two mail-bags full of packages of seeds for distribution to the Central and sub-stations. This extensive collection included varieties of corn, melons, lettuce, turnips, radishes, beans, egg-plant, peas, celery, tomatoes, and other garden vegetables, besides tobacco, grasses, and forage plants. Hon. Stephen M. White also sent some twenty packages of Department seeds, which were redistributed, together with a part of the seeds sent direct from the Department, to individuals who have agreed to report results.

The Assistant Secretary of the Department also sent four packages of Sunn Hemp seed (*Crotalaria juncea*); this was subdivided, and sent to the sub-stations, and to a few individuals, with directions for culture.

The Department also forwarded seeds of Cata-Caos cotton, from Peru. This cotton is further described in the report on the Southern California Station. Also from the Department, selected chestnuts from Mount Etna.

The Pomological Division sent seeds of Persea gratissima (the "avocado" of Mexico). The seeds were gathered from trees that stood a temperature of 22° at the blooming season, and are believed to be the hardiest strain of this noted fruit.

From Don Luciano Santa Maria, U. S. Vice-Consul, Medallin, United States of Colombia:—Seeds of the "Comino Crespo" tree.

From Nathaniel Meirs Cox, of Santiago, Chile:—Seeds of twenty-seven species of Chilean trees, shrubs, and vines, with valuable descriptive notes. An important and interesting collection mostly gathered upon Mr. Cox's estate, Mansel.

From Dr. L. Trabut, Director of the Jardin d'Acclimatation du Hamma, Algiers:—Forty-two varieties of cereals, chiefly wheats and barleys. This collection includes some very large and fine milling wheats, and the size of the kernels of both wheat and barley is extraordinary. From the same botanic gardens came seeds of Fraxinus dimorpha, which were sent to the Forestry Stations.

From the Botanic Gardens of Florence, Italy:—A collection of seeds, including some rare South American palms.

From the Royal Gardens at Kew, England:—Thirty-eight packets of rare seeds, which include three species of Berberis, five of Cytisus, two of Eleagnus, four of Acer, four of Pyrus, seven of Alnus, four of Cratægus, two of Cornus, and others of interest and value.

From Robert Veitch, seedsman, Exeter, England:—Ten packages of new varieties of flowers and vegetables, distributed to the Central Station and sub-stations.

From Baron Ferd. Von Mueller, Government Botanist, Victoria, South Australia:—Seeds of Gordon Pasha cotton, Pesco melon, several varieties of Atriplex, and some thirty packets of valuable seeds from Australia. Also, collection of eighty-two species and varieties of grasses, clovers, economic and forage plants, and garden vegetables, chiefly from South Asia.

From the Royal Botanic Gardens, Calcutta, India:—Three packages of rare tree seeds, with others to follow.

From the Botanic Garden at Saharanpur, Northern India:—A very fine collection of seeds of thirty-three species of Indian trees, and fourteen kinds of vegetables. There is certain to be something of value to California in both the above-mentioned collections.

From W. Farrer, New South Wales:—Through the courtesy of J. E. Watson, of San Francisco, a collection of new Australian wheats, also seventeen hybrid wheats, his own crosses; sent for further tests and developments under California conditions.

From A. B. Robin, South Australia:—Seeds of Para Grove tomato, a new variety of good local reputation.

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FOOTHILL STATION BUILDING, JACKSON, AMADOR COUNTY.

B. THE FOOTHILL STATION.

Five miles north-northeast from Jackson, Amador County.

By CHARLES H. SHINN.

The work of the Experiment Station during 1893 has been along the track outlined in the previous reports. A new vineyard has been planted on a slope of the smallest of the three hills of the Station farm. The orchards, both on the granite and on the red soils, have received additions. Considerable clearing has also been done, and in such a manner as to leave fine specimens of our native trees scattered over the tract. Brush, stones, and logs thrown across several gulches have retained much of the "wash" from higher slopes, and thus the formation of level "flats" for cultivation has been greatly assisted. More stone wall has been built, and some of the worst portions of the road drained permanently by stone channels at the sides. A new hay barn and tool shed has been added to the permanent improvements of the Station, the old stable and shed affording insufficient accommodation.

The General View.—A general view of the Station work for the year is upon the whole encouraging, though it is a large piece of ground to handle with no more labor than we are able to spend thereon. It is necessary for us to care for long stretches of mountain road, and this is both difficult and expensive. Labor and supplies of every sort are more expensive than in the valleys. The birds and wild animals trouble the vineyard, orchard, and garden. Visitors seldom find their way to the Station, and few of those who do come are farmers or interested in any department of horticulture. There is no community of farmers and fruit-growers close to, and surrounding the tract, as there is at the other outlying stations. In all essential particulars, the Sierra Foothill Station is an outpost thrust out into a sparse population of miners, teamsters, lumbermen, stock-raisers, and scattered agriculturists. Constant warfare against difficult conditions is the price of its existence; it is like one of the old border marches of the days of chivalry, a frontier settlement to be kept by the strong hand.

The long, narrow, hour-glass shaped county of Amador has horticultural possibilities quite as great as those of Placer, but Placer has the railroad extending through almost its entire length, while much of Amador is inaccessible except by a stage or private conveyance. As a result, Amador is in precisely the same condition as much of the fine hill country of the lower Sierra—the mining period is passing, but the fruit-growing and gardening period is not yet above the horizon. Men are not planting orchards; land holdings are becoming larger instead of smaller; in many cases magnificent water supplies, capable of irrigating vast areas, are running to waste. This condition of affairs, however, cannot endure. Means of communication will improve; tourists and campers will crowd the upper portion of the county, and little by little

the famous old group of mining towns scattered along the "mother lode" in the heart of Amador, will grow into closer relationships and stir with new life. Like Butte and Placer, Amador will, sooner or later, attract settlers of the horticultural type.

At present and for some years to come, the work of the Station is less local and more for a large district. One of its orchards is upon soil of the coarse, thin, granitic type, so common in the Sierra, and so universally condemned as "too poor to grow pasture." Another orchard is upon the red soil that has produced such excellent fruits in other Sierra districts. Trees and grapevines are being duplicated on these two most typical soils, and it has already been shown that the granite soils are well adapted to many cultures, and respond rapidly to the proper fertilizers. One of the best four-year-old cherry trees on the whole Station tract, photographed for the Midwinter Fair, was a "California Advance," on granite soil, grown without fertilizers or irrigation, and most of the orchard trees have done fairly on this soil.

The general aspect of this picturesque mountain station is both pleasing and impressive, from all its approaches, lying as it does across and among a group of three hills and over a long rocky ridge well covered with pines, oaks, manzanitas, and other native growths. The Station will amply repay a visit from any mountain farmer or fruit-grower. Stage lines reach Jackson from Valley Springs, Ione, and Volcano. May and June are probably the most pleasant months in which to visit the Station, but fruit-growers would find more to see in September.

THE ORCHARD.

The effort to plant similar orchards on granite and red soils has made greater expense than was expected, and will continue to do so for some time to come, but as it is obviously impossible to tell beforehand what varieties will thrive better or worse on either soil, it becomes necessary to duplicate all kinds, and watch results. Small, compact orchards, well arranged and thoroughly studied, are better from every point of view than large, mixed orchards. We have therefore confined the representation of varieties, with few exceptions, to one tree of each variety on each soil, and have made the divisions of sub-orchards as distinct as practicable.

Quite a number of seedlings are in the orchard; some of these were planted by the late Inspector as tests and for future stock; others have grown from the stocks of dormant buds that failed. These seedlings, and some varieties that are mentioned under sub-heads, are now ready to be top-worked with new fruits as fast as desirable, and form a new orchard asset.

Indeed, if I were planting an experiment orchard on soil of a uniform grade, I should try to proportion the various sub-orchards as nearly as I could to the probable demands of the future, and should set in orchard form enough seedlings to enable new introductions to be top-worked, thus saving the loss of time incurred by propagation in nurseries. In many cases we should find after a few years that we only needed a branch or two of some varieties, and one tree could thus carry several sorts. We shall discard much in time, but for purposes of study and comparison the more extensive our lists are in some directions, the better it will be.

THE SUB-ORCHARDS.—At the Foothill Station we now have on the granite soil sub-orchards of cherry, plum and prune, apricot, pear, apple, and almond. To these we shall add nectarines, figs, Japan persimmons, and other fruits. The territory at our command for this orchard being so nearly filled, we shall lay out a new granite soil orchard whenever it becomes necessary. When the few remaining gaps are filled, the present orchard will contain 279 trees. It occupies the lower portion of the northeastern slope of Reservoir Hill, and extends from the granite soil vineyard to a line of mulberries along the road by the mining ditch. On the east are eight olives, in the olive avenue. If the Station could obtain a few acres more of land on the north, both the orchards on the granite and the red soil could be extended with greater ease.

On the red soil there are sub-orchards of pear, apple, plum and prune, nectarine, apricot, peach, almonds, and cherries, while olive, chestnut, fig, persimmon, walnut, and other fruits are represented. The main orchard on this soil occupies the northwestern corner of the tract, extending from the main entrance and olive avenue to the north line. A small addition to the orchard extends south across the avenue, on a slope of Residence Hill. The almonds are on a southern slope of Reservoir Hill, parallel to the olive avenue, and the cherries are below and east of this avenue, in a very sheltered nook. When all the gaps are filled, these sub-orchards on the red soil will contain 557 trees, and some extension southward is practicable.

There is, however, no more room in the apple sub-orchard, and a new one must soon be established. The pear orchard, on the contrary, contains room for many more of the new and promising varieties now obtainable through our correspondents.

The varieties represented at this Station, as at the others, will be found tabulated in the supplement, together with home-station orchards.

Apples.—The list represented here is not sufficiently extensive for so wide and varied a mountain district. Apples do fairly well, and in some cases particularly so, and we can place here our new Southern apples, many Western varieties, and some new ones from England and France. Mr. Hansen reports of the apple orchard generally: "Growth healthy and promising. Three trees showed blossoms." It will probably be necessary to extend the red-soil apple orchard down the slope toawrd the main entrance, on a light soil unsuited for further pear trials.

Almonds.—The climatic difficulties of the district reveal themselves distinctly in the culture of the almond. Although the fig grows and fruits well, the almond is still a doubtful crop, though some varieties promise fair success. The growth of all the varieties represented at the Station was excellent. Sultana and Paper-shell both blossomed very heavily in the spring of 1893, but the flowers were destroyed by a fall of snow in March. Sultana bloomed a little afterwards, but with poor results. Drake's Seedling and Languedoc blossomed later, just after the snowfall, and developed excellent nuts. I X L also yielded a little. Under the circumstances, it is remarkable that any almonds at all were obtained.

The following table will exhibit some details respecting some of the above-named varieties, all that fruited to any extent:

Variety.	First Leaf.	Full Leaf.	First Flower.	Full Flower.	When Ripe.	No. of Nuts.
I X L	Mar. 27	April 7	Mar. 3	Mar. 9	Aug. 27	89
Languedoc	April 6	April 19	Mar. 7	Mar. 27	Sept. 7	367
Drake's Seedling	April 1	April 14	Mar. 8	Mar. 20	Sept. 5	172
Sultana	Mar. 22	April 4	Mar. 6	Mar. 8	Aug. 18	51

This table is instructive and can well be compared with the almond table in the report on Paso Robles Station. The late-blooming varieties are all that it will do to plant in such districts. The old Languedoc, a poor bearer in valley districts, where hundreds of acres are in almonds, is, so far, more reliable than the Sultana or I X L. The reason is plainly to be seen in the blooming period. Languedoc flowers began to show March 7th, two days before the snow, and through the first few days blossoms were probably lost. The tree, however, continued in bloom till March 24th. Five sixths of the crop had therefore a chance to develop. Drake's Seedling might do better another year, and the Bidwell's Mammoth Hard-shell would probably be safe. The present season will be a very important one in the history of the almonds at the Station. At Colfax, in Placer County, as reported by Mr. Chas. Evans, "soft-shell" almonds have not fruited for several seasons, the late frosts killing the flowers. Commercial almond-growing is considered a failure there.

Apricots.—The Station has the beginnings of a most excellent collection; several sorts represented here (among them Boulbon and Esperen) are not yet in any of our other orchards. Many of the trees are making a strong growth, and are extremely healthy. The apricot often does fairly on both the granite and the red soils, but one strange difficulty occurs—sometimes a tree "dies piece-meal," branch by branch, when nothing out of the way can be discovered with root or stem. Mr. Hansen reports a loss of six trees on the granite and of three on the red soil, most of them among the oldest and best trees. Those on the red soil received some sub-irrigation through the berry rows, but the granite-soil orchard received no water. The old settlers say that many apricot trees die in this manner, even when very large trees, both on the level bottom lands and on the ridges.

Like most of the Station fruits, the apricot is a favorite of birds, squirrels, and other marauders. The following table exhibits the only two varieties that bore fruit.

Variety.	First Leaf.	Full Leaf.	First Flower.	Full Flower.	When Ripe.	No. of Fruits.	Fruit to a pound.
Beauge	April 5	April 15	March 22	March 29	July 14	212	11
Hemskirk	April 7	April 15	March 27	March 5	July 15	64	7

This tabulation, though too scanty for many deductions, illustrates the shortness of the probable apricot season in this region. The long period of equable and comparatively cool weather so common in the best cherry and apricot regions of the Coast Range is entirely lacking here; one week brings out the flowers, and a second week the leaves,

while in less than a week from the first ripe apricot, both varieties had yielded their whole crop. However excellent this feature may prove for those who wish to dry apricots on a large scale, it is not an advantage for the canner, or for the planter of family orchards.

Plums and Prunes.—The hill-country is eminently well adapted to standard and late-blooming plums and prunes, as well as to the peach, but there are many local difficulties to be overcome, as the founders of many of the most prosperous mountain colonies have discovered. A great deal of fruit set on many trees at the Station, but the birds "completely plundered the early kinds." Mr. Hansen writes, "Burbank and Kelsey in particular had nice crops, but I did not get one single fruit in a perfect state; most of them were eaten or knocked off before they were half grown." The fruit was remarkably sweet in those cases where any were allowed to ripen; nearly all the trees show a superb growth, and blossomed very freely in the spring of 1893. The plum and prune sub-orchard on the red land has been frequently visited by bands of deer that browsed on the leaves and fruits. They preferred the plums to apples or peaches and spoiled the shape of many trees. Their visits are made at night, and no ordinary fence is any bar to them. As the trees get larger, they will become too sturdy to suffer to any great extent, but here, as in many other districts, the horticulturist suffers heavy losses for the benefit of the sportsman and camper. The only plums and prunes of which any fruit could be saved are reported in the following table:

Variety.	First Leaf.	Full Leaf.	First Bloom.	Full Bloom.	When Ripe.	No. of Fruit.	Lbs. to Tree.
Prune d'Agen	April 18	April 27	April 7	April 11	Sept. 29	183	17
Columbia	April 27	May 5	April 20	April 25	Sept. 14	238	8
McLaughlin	April 20	April 23	April 19	April 27	Aug. 9–19	57	8
Prince Englebert	April 20	April 28	April 20	April 25	Sept. 14–18	96	16
Datte de Hongrie	April 26	May 1	April 26	April 30	Sept. 17–20	97	32
Victoria	April 20	May 1	April 18	April 21	Sept. 14	88	10

All these are five-year-old trees, grown without irrigation, on the hill-sides. The large yield of the sweet and firm Datte de Hongrie, nearly twice that of the ordinary French prune, is worthy of notice. McLaughlin is a fine old sort, of large size, small pit, and very good quality. Prince Englebert is described as "exceedingly rich in sugar." At Colfax, I am told, the late frosts usually destroy the early-blooming Japanese plum fruits.

Cherries.—Only half a dozen varieties have yet fruited. Olivet bore a large and promising crop, but the birds carried every one away. It will be necessary to protect the fruiting trees, another year, with mosquito netting, if any tests are to be made. The Station is so surrounded by wild lands, that poisoning or shooting even large numbers of birds must have little effect.

The dying "branch by branch" disease, noticed in the apricots, is well shown in the cherry trees. First "one branch wilted, then another," till the entire tree above the graft perished. No borers were present, nor was there any unusual gum-flow as is common in the valleys. The trees already lost when of good size are Black Eagle, Empress Eugenie, and Black Tartarian. The Reine Hortense tree will be the next one to die. The Report of 1888–89 mentioned the fact that

a great deal of gum was flowing from the cherry trees, but it disappeared the following year, and comparatively little has been seen since. There is more, in fact, now, than for several years past. Mr. Hansen reports the case of a large tree at Sutter Creek dying from this disease. It would be useful to know the system of pruning followed in this Sutter Creek case.

Nectarines.—Two nectarines, Early Newington and Victoria, bore fruit, but some "person or persons unknown" carried off the small crop before it could be gathered.

Pears.—The pear orchard is undoubtedly the most difficult sub-orchard at the Station. It is in the western part of the tract, between olive avenue and the corner, extending up the slope from the main entrance. Six rows were planted here, and well planted, five years ago. The first row, along the fence, subject, of course, to the evil influences of trees, brush, and grass outside, is practically dead now; the second is almost dead; the third can be called alive; fourth, fifth, and six show successive improvement. Even the hardy and rapid-growing Japanese seedlings have done very poorly in the first three rows, and are not even fit for stocks. The soil of the long slope set to pears is too light and porous, very different, though red in color, from the rich, red clays of the true fruit soils; it contains much quartz-gravel, derived from ledges traversing the regular slate.

The Apple Orchard.—Apples, so far as observed, do much better on this soil than the pears, and as there is need of more space for apples, they will probably be extended to the olive avenue, leaving rows four, five, and six to constitute the pear orchard. It may prove that a third plantation of pears on the strongest soil of the Station will be necessary before a success can be made of the fruit. The growth of the pears on the granite soil is much better.

Peaches.—Observations upon peaches have been more complete than those upon any other sub-orchard. The main orchard is on red soil, southern and southwestern exposures, and somewhat sheltered from the winds. The lesser orchard, on granite soil, was planted later, and is not so well situated, while the soil is poorer; nevertheless, a fair growth for mountain land has been obtained even here.

The oldest peach trees were planted in the winter of 1888, and are now yielding fruit. The soil received no irrigation, nor fertilizers of any description. It was rough hillside land, to begin with—such land as exists over an immense territory in California. As a rule, the peach orchards heretofore planted in this part of Amador County, in pioneer days, were upon richer and more moist soils. Allowed to overbear, and seldom or never pruned, they soon ran wild, and became valueless. Many such old orchards were cut down for firewood. In the warm and fertile Ione Valley, more accessible to outside markets, many fine peach trees are found.

The spring of 1892 was a very early one at the Experiment Station, but that of 1893 was quite late for the district, as the following table shows:

Variety.	Bloomed.		Ripened.	
	1892.	1893.	1892.	1893.
Chinese Cling	Mar. 8	April 7	Aug. 17	Aug. 24
Nichol's Orange	Mar. 8	April 11	Sept. 4	Sept. 10
Jennie Worthen	Mar. 21	April 14	July 7	July 13

These three represented the earliest, the mid-season, and the latest blossoming varieties, and, as noted, the season of bloom was from three to four weeks later in 1893 than in 1892, but in actual ripening the delay was only six or seven days. No appreciable difference in size of flavor was reported between the peaches of the two seasons, 1892 and 1893.

As at the other stations, peaches that ripen the earliest fruit show leaves and flowers later, not earlier than other varieties. Out of sixty-two varieties listed at Amador, nine of the twelve that were last to blossom (after April 1st) belong to the early half-cling type. This and other points are illustrated in the following table, which gives the statistical record of the peach orchard on red soil. All the trees were on peach roots; and all of the trees represented, except Ulatis, Grover Cleveland, Mary's Choice, General Bidwell, and Thisell's White, are five years old; those named are one year younger.

The peach tables from other stations have been arranged alphabetically, but in the original table, as prepared by Mr. George Hansen, foreman of the Amador Station, the peaches were arranged in order of ripening, and it has been thought best to retain this order, for one season, at least. Comparative notes on some varieties follow the table:

Statistics of Peach Orchards—1893.

Variety.	First Leaf.	First Flower.	Ripening Season.	No. of Fruits.	Weight in lbs.
Alexander	April 14	April 2	July 8–17	114	23
Briggs' May	April 12	April 1	July 8–13	15	6
Shumaker	April 12	April 1	July 10–16	167	30
Governor Garland	April 12	April 1	July 10–16	213	36
Jennie Worthen	April 14	April 3	July 11–18	66	11
Waterloo	April 17	April 1	July 13–16	51	9
Amsden	April 12	April 2	July 13–15	38	7
Ulatis	April 15	April 2	July 15–18	104	26
Early Rivers	April 4	March 26	July 20–29	384	64
Strawberry	April 11	March 31	July 21–26	89	15
Hale's Early	April 14	April 2	Aug. 3–7	109	17
Early Rose	April 1	March 29	Aug. 12–14	20	3½
Tuskena Cling	April 3	March 29	Aug. 12–24	209	42
Foster	April 9	March 29	Aug. 14–24	71	14
Coolidge's Favorite	April 8	March 27	Aug. 14	14	3
Early Crawford	April 4	March 29	Aug. 15–23	108	22
Chinese Cling	April 4	March 25	Aug. 19–27	62	21
Royal George	April 10	March 30	Aug. 22	24	4
Grosse Mignonne	April 8	March 29	Aug. 23–29	265	30
Mary's Choice	April 6	March 31	Aug. 23–29	60	9
Noblesse	April 13	April 3	Aug. 24–29	144	20
Honey Cling	April 5	March 27	Aug. 25–Sept. 1	82	14
Elberta	April 6	March 26	Aug. 25–Sept. 2	155	34
Large White Cling	April 5	March 30	Aug. 27–Sept. 3	93	18
Muir	April 12	April 1	Aug. 28–Sept. 7	167	30
Late Crawford	April 1	March 29	Aug. 29–31	45	10
Albright's Cling	April 2	March 29	Sept. 1–6	76	22
Susquehanna	April 6	March 29	Sept. 2–7	52	10
Newhall	April 2	March 29	Sept. 2–6	253	72
Oldmixon Free	April 4	March 30	Sept. 2	23	4
Grover Cleveland	April 7	March 30	Sept. 4	28	7
Wheatland	April 4	March 30	Sept. 4–6	96	24
Runyon's Orange	April 11	March 31	Sept. 4–9	123	35
Seller's	April 2	March 30	Sept. 5–7	101	30
Heath's Cling	April 7	March 30	Sept. 6	60	13
Mrs. Brett	April 7	March 28	Sept. 6–12	300	60
Lemon Cling	April 2	April 1	Sept. 6	63	16
Oldmixon Cling	April 3	March 28	Sept. 6	42	10
Morris White	April 7	March 30	Sept. 8	47	9
Nichol's Orange	April 9	March 30	Sept. 9–14	120	24
California	April 1	March 30	Sept. 9	74	12
McDevitt's Cling	April 8	March 29	Sept. 11	42	11

Statistics of Peach Orchards—Continued.

Variety.	First Leaf.	First Flower.	Ripening Season.	No. of Fruits.	Weight in lbs.
Picquett's Late	April 9	March 30	Sept. 14	57	12
Lovell	April 5	March 30	Sept. 14–16	158	26
Stump the World	April 5	March 26	Sept. 14–17	196	39
Late Admirable	April 9	March 27	Sept. 14–16	148	29
Indian Blood	April 8	March 28	Sept. 14	104	16
Columbia	April 5	March 30	Sept. 14–16	56	19
Thissell's White	April 7	March 30	Sept. 27–Oct. 1	61	14
Garey's Hold-On	April 5	March 29	Sept. 28–Oct. 2	90	30
Crimson Beauty	April 7	March 29	Sept. 29–Oct. 2	167	56
Beer's Smock	April 10	March 27	Sept. 29–Oct. 1	203	40
Smock Late Free	April 9	March 30	Sept. 30	24	5
Salway	April 13	March 29	Oct. 1–8	73	16
Wilkins' Cling	April 8	March 31	Oct. 1	25	5
Bonanza	April 9	March 26	Oct. 2	69	17
Wager	April 7	March 29	Oct. 2–14	211	46
Henrietta	April 10	March 31	Oct. 2–14	267	67
Ward's Late Free	April 4	March 31	Oct. 2–7	35	6
George's Late Cling	April 1	March 29	Oct. 6	56	10
General Bidwell	April 10	March 28	Oct. 27–Nov. 2	42	8
Bilyeu's Late	April 5	March 25	Oct. 29–Nov. 4	31	5

The following notes upon the above varieties complete the story of the season:

Alexander, white-fleshed, semi-cling, yielded excellent fruit. The tree was thinned on June 20th, taking off ten fruits. Time of leafage (*i. e.*, of coming into full leaf,) 19 days; of flowering, 9 days.

Briggs' May (California origin), white flesh, semi-cling, was best of early varieties; pit small, no thinning.

Shumaker, yellow flesh, nearly free, is a highly colored variety; time of leafage, 21 days, of flowering, 13 days. Thinned twice, 53 peaches taken off. Good example of an important type—that of the extremely early yellow peaches.

Governor Garland, white, semi-cling, is well-colored, with a pleasant acid. Like Shumaker, it is a heavy bearer; thinned twice, and 121 peaches taken off.

Jennie Worthen, nearly free, yellow flesh, was heavily thinned, and 134 fruits taken off. It needs further testing.

Waterloo, white, and semi-cling, is a trifle bitter at the pit; it is a well-colored fruit; was thinned once, and 27 peaches taken off.

Amsden, another white semi-cling, has a somewhat acid fruit, and lacks in juice, here.

Ulatis, seedling of Alexander, and earlier in some localities; it has a white flesh, semi-cling like its parent, and is of California origin; somewhat acid.

Early Rivers, freestone, of pale straw-color, short leafage period, but has a blossom period of 14 days. The fruit is of fair size and quality; it was thinned very heavily—562 peaches being picked off, and 384 left to ripen. This weighed 64 pounds—one of the heaviest crops in the orchard.

Strawberry, white, freestone, red at pit, very highly flavored, and exquisitely colored. It was thinned well, 137 peaches being taken off.

Hale's Early, red flesh near skin, freestone, "too sweet to be pleasant." It was thinned heavily, 224 fruits being taken off. This may not be true to name, as it should ripen with or before Strawberry.

The above eleven varieties seem to have ripened in a somewhat different order from that which obtains in the valleys. Professor Wickson's "California Fruits" gives the approximate order of some leading varieties of the early class, as follows: Briggs' May, Alexander, Amsden, Ulatis, Waterloo, Governor Garland, Early Rivers, Hale's Early, Strawberry. In practice, the "first early" varies in different seasons. It sometimes happens that Alexander, Briggs' May, and Amsden ripen nearly together. Ulatis, at the Amador Station, was one week behind Alexander, but in Solano County it ripens quite as early. A break of five days between the first ripening of Ulatis and of Early Rivers marks the passing of the "first earlies," and with the Strawberry the highly-colored, fragrant, "rare-ripe" types begin. Early Rose, a rather dry, small peach, bridges the gap to the clings and the market yellow peaches; the Red Rareripe and Amelia are better peaches for the season, but have not yet come into bearing at the Station.

Tuskena Cling (the Tuscan and Tustin of many catalogues), the earliest cling at the Station, and different from Tuscany, showed many doubles. Thinning took off 114 peaches, and left forty-two pounds. It ripened practically with Foster, Coolidge's Favorite, and Early Crawford. Of these three standard varieties, Foster bore fairly well; fruits large and good quality, needed little thinning. Coolidge's Favorite did very badly, even after 168 fruits had been taken off, leaving the tree seemingly able to carry the crop. The fruit did not appear to mature well, though highly colored. Something of the same sort occurred with this variety at Paso Robles. It should probably be discarded, as there are better kinds for the season. Early Crawford, after light thinning, matured excellent and highly colored fruits.

Chinese Cling, the type of a large number of varieties, chiefly originating in the Southern States, is a very large, oblong peach. At Amador Station it is well flavored, red near the pit, flesh white and juicy, but very downy.

Royal George—"Too sweet to be agreeable," but highly flavored, is the report from the Station. This is a similar peach to the Red Rareripe, or Large Red. Another old variety of European origin, Grosse Mignonne, required heavy thinning (164 fruits), and was still poor in quality. Two similar peaches pass under this name in the United States. The true old French variety has a large flower, and ripens with the Foster, or earlier. Mary's Choice, a large, yellow freestone, of the Crawford type, ripened with Royal George.

Noblesse, a fine old English variety not often grown in California, is reported by Mr. Hansen as "very high flavored." This variety was seventeen days coming into leaf, and was ten days in flower—rather long periods for its type. The pale-green skin, sometimes clouded with light red in the sun, gives this peach a singularly colorless appearance.

The Honey Cling represents a very attractive new type, popular in the South. There is no sweeter or more highly colored peach in the collection. In thinning, 184 fruits were taken off, as the tree was small, and the 82 left weighed 14 pounds.

Elberta and Susquehanna are both good, large yellow; Muir and the Late Crawford fill in well between them—the total range of the four sorts being about a fortnight. A coarse down grows on Elberta, and to a lesser degree on Susquehanna. All of these color up well in the

mountains, and would make good shipping peaches. All required considerable thinning, from 45 to 167 fruits being taken from each tree.

Newhall, a most excellent yellow peach, of California origin, bore 253 fruits, weighing 72 pounds, the heaviest crop in the orchard. The fruit was firm, juicy, highly colored, and ripened in four days. This variety in the valleys usually ripens a week before Crawford's Late; in this case it ripened four days later.

Among the main crop clings, Albright, an El Dorado County seedling (yellow), had very large fruit, sweet and well flavored. The Large White Cling, an old New York variety, was of medium size, highly colored, excellent. Slightly earlier than Albright's.

Grover Cleveland, a yellow cling originating at Vacaville, also Runyon's Cling and Seller's Cling, both California yellow peach seedlings, and all three standards for canning and market, were notable among the peaches of the first week in September. Immediately after Seller's comes the classic Heath Cling, the fruit of which was cracked by showers that did not affect the California seedlings or the fine Lemon Cling of South Carolina, or Oldmixon Cling, both of which ripened at the same time with Heath Cling—September 6th.

The notable freestones of the first week in September were the yellow Wheatland, of New York, juicy, high-colored, and very beautiful, and Mrs. Brett, a very famous variety, thriving in many districts. Though nearly 300 fruits were picked off, as many were left to ripen, and 66 pounds was the crop. Medium size, flesh white, red at pit, sweet and rich.

Morris White, which ripens the second week in September, is "almost without color," but very sweet, juicy, and spicy. This is an old favorite for canning and home use. Almost identical in time of ripening are Nichol's Cling and California Cling, both of them rather coarse, large, Orange Cling type, made familiar in Runyon's and Seller's, and both of California origin. Nichol's was much the better peach. The other was not first-rate in any particular. Two days later, the McDevitt's Cling, a Placer County seedling, began to ripen large, solid, but uneven fruit.

Six peaches began to ripen September 14th—Picquett's Late, Lovell, Stump the World, Late Admirable, Indian Blood Cling, and Columbia. All but one of these are freestones; the first two named are yellow. Lovell ripens here a week later, proportionately, than in the valleys, where it usually comes in with Grover Cleveland Cling. Stump the World, a very poor peach at Paso Robles, and rather losing ground everywhere, has no particular excellence here, but ripens very late for the variety; it belongs to the Oldmixon Free season, which peach it much resembles. It is fully a fortnight ahead of Picquett's Late. The Indian Blood Cling, which seldom is of any value on the lowlands, becomes "very sweet and highly flavored."

There is a notable break of eleven days between the last ripening of Columbia and the first of Thissell's Free, the latter an unusually white peach, delicious flavor, one of the best. Though this peach seems true to variety, its extreme lateness is worthy of notice. Professor Wickson lists it between Crawford's Late and Seller's Cling, which would make the Amador season over three weeks after time.

As observed at the Station, Thissell's Free ripens about with Garey's Hold On and Crimson Beauty. The last named is usually considered as belonging to the Smock season, and the Hold On to a period ten days later; in fact, so late as to be of little or no value in the coast districts.

But Beer's Smock and Smock's Late Free ripened within two or three days as early as Thissell's Free or Garey's Hold On, while Wilkins' Cling and Salway came in still later, October 1st, and no less than four varieties, Bonanza, Wager, Ward's Late Free, and Henrietta, ripened fruit on October 2d. Continuing in order of ripening, we have at Amador Station, George's Late Cling, October 6th; then General Bidwell, October 27th; lastly, Bilyeu's Late, October 29th and until November 4th.

From the standpoint of the valley fruit-growers this order of ripening is almost incomprehensible. This can best be illustrated by parallel columns, showing the leading late varieties:

Order of Ripening at the Station.	Order of Ripening in Alameda County.
1. Seller's Cling.	1. Morris White (4th in station list).
2. Heath Cling.	2. Stump the World (9th in station list).
3. Mrs. Brett.	3. Thissell's Free (10th in station list).
4. Morris White.	4. Seller's Cling (1st in station list).
5. Nichol's Cling.	5. Nichol's Cling (same as in station list).
6. McDevitt's Cling.	6. Lovell (8th in station list).
7. Picquett's Late.	7. General Bidwell (16th in station list).
8. Lovell.	8. Ward's Late Free (15th in station list).
9. Stump the World.	9. Picquett's Late (7th in station list).
10. Thissell's Free.	10. Smock's Late Free (12th in station list).
11. Garey's Hold On.	11. Salway (13th in station list).
12. Smock's Late Free.	12. Mrs. Brett (3d in station list).
13. Salway.	13. Heath Cling (2d in station list).
14. Wilkins' Cling.	14. Wilkins' Cling (same as in station list).
15. Ward's Late Free.	15. McDevitt's Cling (6th in station list).
16. General Bidwell.	16. Garey's Hold On (11th in station list).
17. Bilyeu's Late.	17. Bilyeu's Late (same as in station list).

This is certainly a striking illustration of the climatic differences between districts of California. The ordinary lists of peaches for home orchards, as well as for commercial purposes, as planted in the valleys, would be entirely unfit for the mountains. If one could plant but six peach trees in such districts as that in which the Station is situated, Mr. Hansen recommends the following: Briggs' May; Foster, or Early Crawford; Elberta, or Muir; Nichol's Cling; Henrietta; Garey's Hold On. For a large home orchard, he recommends the following list, for order of ripening and high-grade quality: Alexander, Shumaker, Strawberry, Hale's Early, Tuskena Cling, Foster, Chinese Cling, Royal George, Honey Cling, Elberta, Muir, Late Crawford, Newhall, Grover Cleveland, Lemon Cling (or Nichol's Orange Cling), Picquett's Late, Indian Blood, Late Admirable, Columbia, Thissell's White, Garey's Hold On, Crimson Beauty, Salway, Wilkins' Cling, Henrietta, George's Late Cling.

This review of the peach orchard might be much further extended, but some important representative varieties must be added, and the granite-soil orchard must also be tabulated hereafter. The most casual student of these reports cannot have failed to observe, however, that especial success has attended the culture of main crop and late peaches of the Southern and European varieties; also that the California seedlings have not always thriven, varieties originating in the coast valleys being perhaps unsuited to the district. Especial preëminence in the finer types of late clings for shipments fresh, or for canning and drying, is indicated by the results of the season. The quality of the fruit ranges from good to best. In size, the mountain peaches, on unirrigated lands, more nearly correspond to Eastern standards, and would rank as small to medium in the valleys of California.

CEREALS AND HAY.

Expensive experiments with varieties of cereals have not yet seemed advisable at this Station. The mountain farmer raises little grain except for feeding to his stock; the local demand also limits his hay crop. A few standard varieties are all he needs, and the many plots devoted to cereals at other stations would serve no purpose in districts where milling wheats and brewing barleys are not used.

The hay crop is so important locally in the Sierra, where freighting is always expensive, that it justifies much attention from the Station workers. The results of a small trial of fertilizers upon some of the poorest soil on the tract, a light, decomposed granite, were printed in the Report for 1891. In 1892 the experiment was continued under similar conditions, also in 1893.

The following table compiled from data forwarded by Mr. Hansen, will illustrate the conditions. It should be explained that the plots were laid out with a view to obtaining uniform soil. The table covers the three seasons, 1890–91, 1891–92, and 1892–93. The first of these seasons was considered an average year in the neighborhood; rainfall, 18.18 inches. The second season was locally considered an exceptionally good year; rainfall, 28.90 inches. The third season, though it had 40.97 inches of rain, was a poor one in the district. Mr. Hansen wrote concerning it: "The early part of the season was one continuous rain, and the lack of any warm days during that time kept the grain back to an alarming extent. Still, in spite of that, we would have had a fair crop if we could have had late rains. But instead of the usual heavy rains the first week of May, we had hardly any rain at all that month—hence the small amount of hay harvested." Mr. Hansen sowed barley the first season, wheat the second season, and oats the third season upon all the plots tabulated:

Hay Statistics.

	1890-91. (Barley.)		1891-92. (Wheat.)		1892-93. (Oats.)	
	Fertilizer.	Pounds per Acre.	Fertilizer.	Pounds per Acre.	Fertilizer.	Pounds per Acre.
Check-Plot (red soil); area, 9,120 sq. ft.	None.	1,500	None.	1,575	None.	1,750
Plot 2 (pure granite); area, 9,120 sq. ft.	125 lbs. "C" fertilizer.	2,750	50 lbs. bone meal, 35 lbs. nitrate of soda.	5,700	None.	2,200
Plot 3 (one third red soil, the rest granite); area, 18,240 sq. ft.	200 lbs. bone meal and 100 lbs. nitrate of soda.	3,000	150 lbs. br'd C, 50 lbs. bone m'l.	5,900	None.	2,700
Plot 4 (pure granite); area, 18,720 sq. ft.	400 lbs. bone meal.	2,500	75 lbs. nitrate of soda, 150 lbs. brand C.	5,500	None.	2,200
Plot 5 (pure granite); area, 21,120 sq. ft.	225 lbs. nitrate of soda.	2,000	100 lbs. bone meal, 150 lbs. brand C.	3,000	None.	1,100
Days of growth	125		173		167	
Rainfall	18.18 inches.		28.90 inches.		40.97 inches.	
Seed sowed per acre	220 pounds.		180 pounds.		200 pounds.	

All that was needed to make this table complete was the check-plot on the poorest granite soil, and the uniform use of the same grain for the three seasons. But certain conclusions are indicated. Bearing in mind that the poor granite soil, unfertilized, often does not yield five hundred pounds to the acre, the history of plot 5 is instructive. The crop on it was increased to a yield of a ton of barley hay by the use of about 100 pounds of nitrate of soda; by a little additional help, it went to a ton and a half of wheat hay the second year, and enough was left in the soil to furnish a better yield the third year than any new land of the same sort could possibly produce. It is plain that the bone meal and nitrates pay, and pay largely in the granite soils, as illustrated by plot 2. The yield of nearly three tons of barley hay is about two and a half times the probabilities of the same soil, unfertilized, even in a very favorable season. The irregularity in the comparative amounts of fertilizers used on the different plots in different seasons necessarily prevents any very close comparison of results.

The hay plots laid out in the winter of 1893–94, for the coming season, are of a uniform size of one tenth of an acre.

On the granite soil sixteen separate plots have been sown, five of which are in oats and eleven in barley. Of the plots devoted to oats, the fertilization is as follows: Check-plot, no fertilizer; on other plots, respectively: 50 lbs. bone flour; 20 lbs. potash; 50 lbs. brand "B"; 10 lbs. nitrate of soda. Of the plots devoted to barley, the fertilization covers a wider range. Besides check-plots, the following variations are made: 40 lbs. potash; 50 lbs. bone flour and 10 lbs. nitrate of soda; 50 lbs. dried blood and 10 lbs. nitrate of soda; 60 lbs. bone flour; 50 lbs. blood; 50 lbs. brand "B"; 40 lbs. chicken manure; 50 lbs. bone flour. Some of these are duplicated, to better afford comparisons.

On the red soils ten plots have been laid out, besides the check-plots, three sown to oats, the rest to barley. The fertilizers used on the plots devoted to oats are as follows: 50 lbs. brand "B"; 50 lbs. blood; 40 lbs. potash. The barley plots are fertilized as follows: 60 lbs. bone flour; 40 lbs. chicken manure; 50 lbs. brand "B"; 50 lbs. bone flour and 10 lbs. nitrate of soda; 50 lbs. blood; 40 lbs. potash.

The bone flour used in the above experiments, at this and other stations, was a gift from Mr. J. E. Miller, Manager of the California Fertilizer Works, of San Francisco.

FIGS AT THE FOOTHILL STATION.

By GEORGE HANSEN, Foreman.

The fig plantation at the Station encircles Reservoir Hill, beginning 75 feet above the ditch, rising to 140 feet on the Summit, and descending on the other side to about the same level as the commencement. Seventy-six trees are planted here in avenue shape. Most of them are in the rich, red soil so common throughout the foothills; a few, however, are on the granitic soil, though even here it is improved by receiving the "wash" of the red soil on the higher slopes.

The oldest trees on the Station were planted five years ago, and many new sorts have been added from time to time. The yearly growth of the trees is from 12 to 48 inches, and the finest looking tree, White Adriatic, now has a trunk 6 inches in diameter, and stands 14 feet high. No water has been supplied from any artificial source.

The annual extremes of temperature at the Station are usually from 21° to 107° Fahr. No branch nor bud has ever been injured by the cold, though all the trees are alike exposed to the cutting north and east winds sweeping with terrible force over the hills at the beginning of the rainy season, and again in the early spring.

The following varieties are represented:

Agen.
Black California.
Black Bourjassotte.
Brogiotto (black).
Breba.
Brunswick.
Col di Signora Nero.
Datto (white).
De Constantine.
Drap d'Or.
Gros Gris Bifere.
Ladara.
Osborne Prolific.
Petrovaca.
Rubado.
Smyrna.
Trojano.
White Adriatic.
Zimea.
Angelique.
Black Ischia.
Black Dattato.
Brogiotto (white)
Brown Turkey.
Cernica.
Damatino (?)
Du Roi.
Early Violet.
Hirtu du Japon.
Monaca Bianca.
Pasteliere.
Rocardi.
Ronde Violette Hative.
Sanvito.
White Ischia.
White Genoa.
Abondance Précoce.
Black Marseilles.
Bourjassotte grise.
Brianzola.
Brown Ischia.
Col di Signora Bianca.
Dalmatian.
Dorée Narbus.
Guiglione.
Kargigna.
Negra Larga.
Ronde Noir.
Smyrna (Bulletin).
San Pedro.
White Marseilles.
White Bourjassotte.

Most of these figs develop their first leaves in the last week of April. Ladara, the earliest, showed leaves April 20th; Pasteliere on April 21st; Black Marseilles, Brown Ischia, Ronde Violette Hative, on April 23d; last of all came Negra Larga, April 30th, and the extremely hardy Dorée Narbus, May 1st.

Comparisons of varieties, always difficult, are especially so at this Station, as but few trees have been planted, and local conditions vary considerably. Nevertheless, the following memoranda may prove of interest:

Statistics of Bearing Ages.—Those figs that bore the first year after being planted were the Du Roi, Petrovaca, Drap d'Or, Hirtu du Japon, and Early Violet.

The following sorts first bore fruit the second year after planting: Pasteliere, White Genoa, Osborne Prolific, Dorée Narbus, and White Marseilles.

In the third year after planting: Cernica, Bourjassotte Grise, White Adriatic, Abondance Précoce, and Ladara.

In the fourth year: White Bourjassotte, Rocardi, Smyrna (from Bulletin stock), and Breba.

Zimea and Angelique, though five years old, have never set any fruit.

Size of Fruits.—Figs of good size have been borne by the Du Roi, Petrovaca, Pasteliere, White Marseilles (see note 1), White Adriatic, and Drap d'Or.

Fruits of fair size are those of the Breba, De Constantine, Gros Gris Bifere, Smyrna (see note 2), Brown Ischia, Bourjassotte (the black, and the green), Brunswick (see note 3), and Hirtu du Japon.

Figs of small size are those of the Col di Signora Bianca, Black Ischia, and the Dorée Narbus.

Figs so far worthless in this district are the White Ischia and the Black Marseilles.

In the above classification, the expressions "good," "fair," and "small" are only relative, but true up to date. A first-crop Petrovaca fig, picked July 3d, measured 7 by 7½ inches in lateral and longitudinal circumferences. But figs of the later crop measured only 5 by 5½ inches. Monaca Bianca and Brown Turkey were much the same. Such fruits, in this locality, grown without irrigation, can safely be called "large." Du Roi averaged 9½ or 10 figs to the pound; White Adriatic, 8½, and these can be called "fair-sized" for mountain fruit.

Figs that Fell Off.—Breba, reported as losing its fruit at other stations, held part of the crop, though a portion fell off. By August 20th the Smyrna (Bulletin importation) had lost its fruit, and so had the Dorée Narbus; some of the Brown Ischia figs also fell.

First-Crop Figs.—The following varieties entered the winter of 1893–94 with first-crop figs set, and healthy. The numbers, counted on November 28th, are given after each name: Black Bourjassotte, 27; Black Ischia, 18; Black Marseilles, 75; Brunswick, 2; Brown Turkey, 14; Cernica, 13; De Constantine, 27; Du Roi, 22; Hirtu Du Japon, 6; Monaca Bianca, 27; Osborne Prolific, 3; White Ischia, innumerable, and worthless. Similar fruits, set in the autumn of 1892, were ripened into fruit crops by: Black Marseilles, 32; Brown Turkey, 5; De Constantine, 6; Du Roi, 10; Monaca Bianca, 7; Petrovaca, 4.

Foliage.—Some varieties retained their leaves in a green state till November 17, 1893, only dropping them little by little after the frosty gale of that date, when the thermometer fell to 31° Fahr. On New Year's Day, Abondance Précoce, Dalmatian, Black Dattato, Du Roi, Ronde Noir, Sanvito, Trojano, and Brianzola still carried a few leaves.

Figs for Planting.—Notes on the varieties at the stations are necessarily still incomplete, first as to the varieties that bore here, as the trees may behave differently the very next year; secondly, we do not yet have all our sorts in bearing, and lack some varieties grown elsewhere, which we would be glad to obtain, for comparison. Of early figs, the first ripened here in the first week in July. White Adriatic ripened September 4th, and bore till the first week in November. Du Roi has done excellently from the beginning, a choice fruit, bright in color, rich in flavor, sweet in juice. It bore from August 13th till September 12th, yielding 161 fruits. The birds ate fully as many, and a small late crop was set which carried well into the winter. White Marseilles was nearly as good as the Du Roi, ripening August 20th, and continuing till September 12th; total number of figs gathered, 320, and the birds had theirs besides. These were the best white varieties.

The best brown varieties were Drap d'Or, ripening September 1st; lasting till September 12th; crop, 53. Brown Turkey: first crop was excellent; second crop had a rather tough skin and lacked in sugar.

Pasteliere was the best black fig; a deep black fruit with bluish cast, very juicy, flavor rich and sweet. It did not ripen till September 20th, and only bore about twenty pounds. Ronde Noir, ripening at about the same time, also a shy bearer, had deep purple fruits with yellow flesh.

The best bearer of all is Hirtu du Japon, a plump, round, shiny black fruit, lighter in color toward the stem. It ripened about August 20th, and continued till frosts. The crop is so abundant that counting would

be difficult, and the short branching growth indicates that it would be well adapted to culture in pots or boxes in colder climates.

Early Violet, ripening the first week in August, is a small grayish fruit with a bluish shade. It is sweet and welcome, because of its earliness, but is too small to have commercial value.

NOTES (by C. H. S.).—(1) The White Marseilles is a very small fig, as small as the Black Marseilles, and of much the same shape and quality. It has a coarse, acrid skin; distinctly a second-rate fig. I am inclined to think that Mr. Hansen's White Marseilles must be wrongly labeled. It is probably the Grosse Marseilles, a different sort.

(2) This must be the ordinary "White Smyrna," so called, or California; nearly identical with the Dalmatian of our Tulare Station, and called by John Rock identical with the Brunswick. But what Mr. Rock means is, I think, what has been known as "Brown Smyrna." Under any name, this should be one of the largest figs at the Station, larger than White Adriatic. The Bulletin Smyrna dropped its fruit, as is usual with that variety.

(3) The true Brunswick is one of the largest figs known, only surpassed in that respect by Negra Larga.

BUILDINGS AT SOUTHERN COAST RANGE EXPERIMENT STATION PASO ROBLES.

C. SOUTHERN COAST RANGE STATION.

One and a half miles north-northeast from Paso Robles, San Luis Obispo County.

By CHARLES H. SHINN.

General Review of Year's Work.—The season of 1892–93 has been more favorable for plant growth than that of 1891–92. In the Paso Robles district, and in general, I believe, in the hill country of the southern Coast Range, late spring rains are essential to success with annual crops. The orchards, also, need late rains, to give size to fruit. While there is usually rain enough in the district, it does not always come at the best time for the agriculturist. The spring rains of 1893, after March 1st, amounted to 0.88 of an inch, and would have been a greater help had it not been for the long series of drying north winds which began about March 1st and continued till June.

In some seasons the rainfall after March 1st is twice as great, and calm, cloudy weather enables the soil to retain the whole of it. Owing to the north winds the cereals were only an average crop, but the orchards, with deep cultivation, suffered no injury, and made, in fact, a growth surpassing that of any former year.

The climatic table accompanying this report shows the time and severity of the frosts. The coldest nights of 1893 were November 18th and 19th, when the thermometer registered 19° and 20° Fahr. On the 19th, 20th, and 21st of December, 1893, the thermometer registered 22° each night. In the spring of 1892 there was a long period of low temperature, that injured the peach and apricot crop and destroyed the almond and cherry blossoms. The thermometer fell below 34° on sixteen nights in January, seven nights in February, five in March, two in April, and one in May. Nineteen varieties of peach failed to set fruit. The lowest point during the blooming season, March 28th, was 30° and that did the injury.

In the spring of 1893, the thermometer fell below 34° during twenty-five nights in January, seven nights in February, five in March, and three in April, but at the most important period of bloom the temperature fell to 34° on only one occasion. Fifteen of the nineteen varieties of peach that were frosted in 1892, fruited in 1893; but four, Crimson Beauty, Honey Cling, Ulatis, and Strawberry, failed to set fruit, and this may have been due to some frosting of the blossoms.

The summer of 1893 was more temperate than usual, the thermometer going above 100° but once in June, once in July, and twice in August. The highest point reached during the season (July 18th) was 106°. The

following table shows the temperature at the Station for the fiscal year ending July 1, 1893:

Paso Robles Temperature Report for the Fiscal Year 1892-93.

	Daily Mean.	Mean Daily Max.	Mean Daily Min.	Mean Daily Range.	Extreme Max. and Dates.	Extreme Min. and Dates.
1892—July	74.82°	92.87°	56.80°	36.07°	106° 1, 4, 31	50° 2, 3, 6
August	72.09	92.74	51.45	41.29	110 .....17, 20	45 ....10, 11
September	67.33	85.76	48.90	36.86	98 7	40 .....5, 26
October	58.57	75.93	41.22	34.71	94 3	30 17
November	51.72	69.57	33.87	35.70	85 11	24 25
December	44.67	54.96	34.38	20.48	68 25	22 ....18, 19
1893—January	41.16	56.20	32.12	24.08	65 ..14, 25, 28	24 ....19, 21
February	46.77	57.10	36.35	20.75	69 21	26 2
March	49.38	58.35	40.70	17.65	80 29	30 12
April	52.63	65.46	39.80	25.66	82 22	34 ...7, 8, 13
May	61.67	79.38	43.96	35.42	91 30	36 18
June	64.89	81.63	48.16	33.47	101 2	42 ....13, 19

The vineyard was again touched by early frosts, and late grapes injured. The fruit of the olives was mostly destroyed by severe cold. Places within a mile of the Station do not suffer from the frost. It is a peculiarly trying situation for olives, oranges, figs, walnuts, and the late varieties of grapes. Every year's experience in this extremely variable district gives additional emphasis to the need of care in selecting sites for fruit-growing throughout Monterey and San Luis Obispo Counties. In this extensive and fertile region, 100 miles long by 40 wide, there is a great range of climate, and the local conditions must be studied carefully. Rather slow growth and late bearing of orchards are indicated by our experience at the Station.

It should be remembered, in reading the following report, that the soil on which the orchard is planted is mostly light and dry, called by the San Luis farmers "third-rate land," on which most persons in the district thought that no fruit tree would strike root, or live a year.

Change of Foreman.—At the beginning of 1893, Mr. R. D. Cruickshank resigned the foremanship of the Station, and Professor Wickson, Acting Director, appointed Mr. W. H. Tyson in his place. Mr. Tyson is a Californian of considerable experience as an orchardist, and has already made many improvements in the management of the Station. He moved his family into the farm house early in February, and has given steady and faithful service ever since. It is a decided gain to have a family settled on the place that had so long been managed by two men keeping "Bachelor's Hall," and both house and garden already show many changes for the better.

THE ORCHARD.

There is much of interest in the steady development of the young orchard. It is receiving better culture and more systematic pruning than before, and presents as uniform an appearance as can be expected when the differences in soil and varieties of fruit are taken into consideration. Nearly all the trees have made excellent growths, except a few of the apples and cherries, as will be noted in detail under their respective headings.

Mr. Tyson has made seven charts under date of September 4, 1893, showing the age, comparative size, and variety of every fruit tree in the

IMPORTED PERSIAN BROAD-TAIL SHEEP.

plantation, arranged, of course, by separate orchards or blocks, beginning at the south end of the tract and going north. These charts have been extremely useful in preparing this report. When such charts are duplicated at regular intervals of three, four, or five years, they furnish material for many important comparative studies of orchard growth. Such charts or diagrams, if truthful, even though rudely made, are almost essential to a complete history of the Station, and their value will increase with time as successive series of experiments are begun and completed, varieties discarded, old trees regrafted, and new ones planted.

The various lesser orchards of the Station are planted in a continuous belt along the western side of the tract, beginning at a cross avenue and extending from the main central avenue to the boundary line on the west. Between this orchard tract and the county road, the southern boundary of the Station, there is a small vineyard and a portion of the plot devoted to small cultures. Beginning, then, at the south, the cherry orchard comes first, followed in continuous succession by the almonds, apples, peaches, nectarines, apricots, prunes, plums, and pears. While they follow this order in the main, the desire to put trees of a given variety on light or heavy soil, and various other considerations, has prevented the entire separation of the different species. As planting extends up the slope toward the north, on the heavy adobe soil, the mixed character of the central portion of the orchard will doubtless continue, because varieties now on lighter soils will be duplicated on heavier soil.

Cherries.—As the foreman, Mr. Tyson, notes in his report: "The cherry does not seem very well adapted to the soil and climate; considering this fact, the trees have done well." The extreme dryness of the atmosphere is very much against the cherry in the extensive district east of the Salinas, and while it always deserves a place in family orchards, it is not suited to commercial purposes, except where local conditions materially modify the climate. These conditions may occur wherever the Santa Lucia range is sufficiently broken to admit the sea fogs to cañons facing the valley of the upper Salinas. Well-drained bottom lands along the Naciemiento or San Antonio, particularly in the northern slopes of the cañon, would fulfill these conditions, and they might also exist near Santa Marguerita, but seldom on the high plains east of the river.

Most of the cherry trees in the Station orchard are five years old. The largest of these, Windsor and Pontiac, are seven feet in spread of boughs. Five feet across, however, represents the average of five-year-old trees of such standard sorts as Belle d'Orleans, Napoleon Bigarreau, English Morello, Olivet, Black Eagle, Knight's Early, Lewellyn, Lincoln, and Reine Hortense. Between the two grades in size are Burr's Seedling, Willamette, one of three Purity trees, Early Rivers, Coe's Transparent, and Governor Wood. Poor in growth, hardly three feet in spread of branches, are Centennial, May Duke, and Belle Magnifique, Empress Eugenie and one of the Purity trees. Early Rivers, May Duke, and Yellow Spanish show many dead branches, either on account of pruning at the wrong season or because planted where large oaks had been removed when the orchard was established. Black Tartarian, Thompson's Seedling, Chapman, Oregon, and Rockport Bigarreau are but newly planted.

In all, there were forty-one varieties of cherry represented in this

orchard at the close of 1893, with three vacancies to be filled by new trees during the present planting season.

The following table, compiled from Mr. Tyson's memoranda, gives some statistics of the cherry orchard, and serves to illustrate the climatic conditions:

Comparative Table of Cherries—1893.

Variety.	First Flower.	Full Flower.	Blooming Season.	When Ripe.
Belle d'Orleans	March 20	March 31	25 days.	June 8
Belle Magnifique	April 12	April 30	.....	No fruit.
Burr's Seedling	March 28	April 12	20 days.	June 15
Black Eagle	April 1	April 20	25 days.	June 15
Black Mastodon	No blossoms.			
California Advance	April 8	April 18	20 days.	No fruit.
Centennial	April 5	April 19	25 days.	June 20
Cleveland Bigarreau	March 31	April 20	30 days.	June 10
Coe's Transparent	April 16	April 25	30 days.	June 10
Duchesse de Palluau	April 8	April 20	30 days.	No fruit.
Early Rivers	April 5	April 20	25 days.	No fruit.
Empress Eugenie	April 12	April 20	30 days.	June 15
English Morello	April 19	May 3	18 days.	No fruit.
Governor Wood	April 5	April 20	30 days.	June 15
Great Bigarreau	April 4	April 19	25 days.	June 15
Guigne Très Précoce	March 28	April 5	20 days.	No fruit.
Knight's Early	April 5	April 18	20 days.	June 20
Lewelling	April 16	April 25	18 days.	June 20
Lincoln	April 5	April 20	25 days.	June 10
May Duke	April 8	April 20	20 days.	June 10
Major Francis	April 5	April 18	30 days.	June 15
Olivet	No blossoms.			
Pontiac	March 31	April 5	30 days.	June 15
Purity	March 31	April 16	20 days.	June 15
Reine Hortense	April 12	April 20	20 days.	No fruit.
Schmidt's Bigarreau	April 16	April 26	.....	No fruit.
Tradescant Black Heart (1)	March 20	March 31	28 days.	No fruit.
Tradescant Black Heart (2)	April 4	April 20	.....	No fruit.
Werder's Early Black	No blossoms.			
Willamette	April 4	April 16	26 days.	June 10
Windsor	March 28	April 5	20 days.	June 15
Yellow Spanish	April 16	April 25	20 days.	No fruit.

The age of the trees tabulated above is uniformly five years, except in the cases of Centennial, Reine Hortense, Tradescant's Black Heart, Willamette, and Warder's Early Black, which were four years of age. The amount of fruit set was very small in every case, and hence the weight was not determined. All the trees, except Yellow Spanish and Early Rivers, as noted, made fair or even good growth. The foreman notes the firmness of the large, mottled Centennial cherry; the similarity of Coe's Transparent, Purity, and Governor Wood; also that of May Duke and Empress Eugenie. Major Francis resembles the Burr Seedling; Windsor is like Napoleon Bigarreau in shape, dark-red color, excellent quality; the Cleveland Bigarreau is somewhat the same as the Napoleon, and does not seem better. Willamette, a black, round cherry of medium size and good quality, promises to rank well. Lewelling belongs to the Black Republican class, and does not differ greatly from the type form.

In the above table one notes that one Tradescant's Black Heart and the Belle d'Orleans bloomed first (March 20th); Coe's Transparent, Yellow Spanish, Schmidt's Bigarreau, and the Morello were in fair growth; the others were poor trees, so that their blossoming time was probably abnormal.

The time of full flower, a better comparison, varied thirty-three days from Belle d'Orleans (March 31st) to English Morello (May 3d). The

length of the blooming season varied considerably, from the eighteen days of the Morello to the thirty days of the Pontiac, Governor Wood, and no less than five other varieties. The time of ripening covered a season of but twelve days, from June 8th to June 20th. The same varieties in Alameda County would extend over a period of about thirty days. Although this curiously short season at Paso Robles will be lengthened as larger crops are borne, such a collection of varieties in the coast climate would give a much wider range, even the first bearing year. Eleven varieties, however, some of them among the latest, "set no fruit," and it remains for another season to determine the length of the cherry season at the Paso Robles Station.

Almonds.—The foreman reports that "all the almond trees grew exceedingly well, those old enough to bear producing heavily, except the Commercial, which bloomed so early that the blossoms were injured by frost. The I X L is far ahead of any of the other soft-shells now bearing at the Station, and seems in every way adapted to the soil, and hardy enough to stand considerable frost. The I X L nuts were large, well-filled, and uniform, and very bright in color, even before bleaching. It ripens early in the season, being the earliest of all the varieties at the Station, and the husks open well in the latter part of August. Of the soft-shell almonds, the Paper-Shell is next in size of tree to the Sultana; the nut is larger, and preferable on that account; the yield of both is about equal. The only hard-shell bearing at the Station is Bidwell's Mammoth, which bore very well for a four-year-old tree. The nuts are rightly named, for they are certainly of immense size."

The largest almond trees in the orchard are I X L, Sultana, Nonpareil, King's Soft-Shell, Bidwell's Mammoth, Texas Prolific, and Drake's Seedling. The last three are but four years old; the others are five, but all show a circle of boughs over a circle of nine feet in diameter, and all, in general appearance and healthiness, would be thought fine almond trees anywhere. Of lesser growth are Marie Dupreys, Harriott's Seedling, Ne Plus Ultra, Golden State, Languedoc, and Pistache. Still smaller for its age is another Drake's Seedling that stands where one of the ancient oaks was removed. Fifteen varieties of almonds are represented in the orchard. Besides, there are twenty seedlings in orchard form, planted by the late Mr. Klee, who took especial pains to select the stock, but whether cross-fertilized or not, we have no record. These trees can be used to graft new sorts upon, leaving enough of each original tree to test the quality of the seedling.

Comparative Table of Almonds—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Harvested.	Amount Yielded.
Harriott's Seedling	Feb. 1	Feb. 20	Feb. 26	Mar. 10	28 days	No crop.	.....
Marie Dupreys	Feb. 14	Feb. 28	Mar. 6	Mar. 18	22 days	Aug. 3	4 lbs.
I X L	Feb. 15	Mar. 1	Mar. 1	Mar. 15	20 days	Aug. 30	10 lbs.
Bidwell's Mam'oth	Feb. 18	Mar. 1	Mar. 3	Mar. 16	20 days	Sept. 30	6 lbs.
Ne Plus Ultra	Feb. 15	Feb. 28	Feb. 28	Mar. 12	17 days	Sept. 30	1 lb.
Sultana	Feb. 18	Feb. 26	Mar. 1	Mar. 14	22 days	Aug. 21	8 lbs.
Paper-Shell	Feb. 13	Feb. 27	Mar. 8	Mar. 20	23 days	Aug. 21	4 lbs.
King's Soft-Shell	Feb. 23	Mar. 10	Mar. 10	Mar. 26	23 days	Aug. 21	7 lbs.
Drake's Seedling	Mar. 1	Mar. 13	Mar. 16	Mar. 28	22 days	Sept. 30	3 lbs.
Nonpareil	Mar. 10	Mar. 18	Mar. 10	Mar. 30	20 days	Aug. 28	6 lbs.
Texas Prolific	Mar. 3	Mar. 22	Mar. 24	April 4	22 days	No crop.	.....
Pistache	Mar. 13	Mar. 22	Mar. 25	April 4	20 days	No crop.	.....
Languedoc	Mar. 10	Mar. 18	Mar. 18	Mar. 28	15 days	Oct. 1	A few nuts.

The variation of date of first flowering in the case of the varieties of almond is considerable, being, as shown in the above table, from February 1st to March 13th, or nearly six weeks between Harriott's Seedling and Pistache. Most of the varieties begin at the Station about the middle of February, and the period of bloom ranges from fifteen days (Languedoc) to twenty-eight days (Harriott's Seedling). The first leaves come out, in most cases, a week after the period of full bloom, or three or four weeks after the first flower appears, but some varieties leaf out while in the prime of flower. The first almond to ripen is Marie Dupreys (August 3d), and the latest is the well-known Languedoc.

Apples.—A few trees have showed stunted growth on a part of the head, but the foreman believes that this will soon be remedied by later pruning than heretofore. White Winter Pearmain and Fall Pippin bore fruit of fair size and good quality this season. Though the summer climate is very warm, the cold winters particularly suit the apple, and the Station is justified in planting a large assortment. A rather slow but compact growth is to be expected in this district—a dry upland region where it is from 80 to 160 feet to water, but good cultivation has nowhere shown better results than in the apple orchard.

Nearly all the trees, except a few replantings, are five years old. The largest in spread of branches are Bledsoe, Red Winter Pearmain, Long, Red Beitigheimer, English Golden Russet, Missouri Pippin, Bledsoe, and Pewaukee. The boughs of these trees cover a circle of between six and seven feet in diameter. The Russet does better than one would expect. The following varieties are a little smaller: Walbridge, Jonathan, Shirley, Shannon, White Astrachan, Beauty of Kent, Lawver, Alexander, Fameuse, Winesap, Vandevere, Flora Bell, Ribstone Pippin, Mann, and Keswick Codlin. Of almost identical size are Swaar, Yellow Newtown Pippin, Mother, MacMahon, Wolf River, Gloria Mundi, and Ladies' Sweeting, all having made trees of almost four feet spread of branches. Still smaller are the trees of Talman's Sweeting, Wagener, Rome Beauty, and Early Strawberry, and these kinds can be said to be unsuitable to the locality. Fifty-two varieties are represented, and there were also four gaps where trees had died, which were to be filled this planting season, making a total of fifty-six varieties in the apple orchard.

The record of the apple orchard shows that the variety that showed the earliest flowers and leaves was Siberian Crab (March 25th) with Stump and White Winter Pearmain following closely on March 28th; Bledsoe showed first leaves on March 31st; then came an interval of four or five days, when Shannon, Red Beitigheimer, Yellow Newtown Pippin, and fifteen others out of some sixty varieties tabulated, were all beginning to show leaves and flowers. Transcendent Crab, Norton's Pearmain, Baldwin, and a few others bloomed on the 10th. Some twenty-eight varieties began to bloom between the 12th and the 16th. Pewaukee and Red Winter Pearmain were the latest to blossom—April 20th.

With the apple, as with the cherry, the flowers begin to show with the leaves and are fairly out by the time of full leafage. The period between first leaf and full leaf is short with the apple—Winesap and Limber Twig took only five days from April 15th, but ten days is more nearly the average period, and White Astrachan required seventeen days.

The earliest apples, such as Red June and Early Ripe, leafed out and blossomed eight days later than such a famous late apple as White Winter Pearmain. On the other hand, two winter apples, Yellow New-

town Pippin and Red Winter Pearmain showed a difference of sixteen days, and the best keeper is the earliest blossoming fruit. Notwithstanding the similarity of names, the Red Winter and White Winter Pearmain, which bloomed twenty-three days apart, are not related to each other. The Red Winter Pearmain is even known as Red Vandever in Tennessee, and as Red Fall Pippin in the Middle States, and though its origin is unknown, one is tempted to infer Russian Blood in this as in the other early-blooming varieties.

Peaches.—The largest five-year-old peach tree in the orchard is a Mrs. Brett, which is about eleven feet in spread of branches. Other extremely fine trees are McKevitt's Cling, Muir, Lovell, Early Rivers, Foster, Seller's Cling, and Mountain Rose. Nearly equal to these are the Susquehanna, Chinese Cling, Brandywine, Strawberry, General Bidwell, Crawford's Early, and a large number of others. The peach orchard consists of three, four, and five-year-old trees, and is remarkably uniform in growth and quality. Among the poorer growths are Ward's Late Free, Waterloo, California, and Henrietta.

In the orchard there are seventy-three named varieties, besides some duplicates and about thirty seedlings planted by Mr. Klee. Two of these seedlings have now come into bearing. One resembles Crawford's Early, but is much later; the other is of the Muir type, with particularly small pit, and is, as the foreman reports, "the finest peach of its season at the Station." They will, of course, receive further study.

The following tables have been compiled by the foreman for the report:

Comparative Table of Freestone Peaches—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.	Amt. of Fruit.
Amsden	Mar. 22	Mar. 30	April 5	April 14	30 days.	July 8	30 lbs.
Beer's Smock	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 20	40 lbs.
Belle Bausse	Mar. 13	Mar. 27	Mar. 30	April 8	----------	Aug. 8	--------
Bilyeu's Late	Mar. 13	Mar. 30	Mar. 30	April 10	31 days.	----------	--------
Brandywine	Mar. 10	Mar. 27	Mar. 30	April 10	28 days.	Set no	fruit.
Briggs' May	Mar. 22	Mar. 30	April 4	April 14	32 days.	July 1	40 lbs.
Columbia	Mar. 13	Mar. 27	Mar. 30	April 10	26 days.	Set no	fruit.
Coolidge's Favorite	Mar. 13	Mar. 30	Mar. 30	April 6	30 days.	Aug. 12	30 lbs.
Crawford's Early	Mar. 22	Mar. 30	Mar. 30	April 6	32 days.	Aug. 12	30 lbs.
Crawford's Late	Mar. 13	Mar. 27	Mar. 30	April 6	30 days.	Aug. 30	40 lbs.
Early Rivers	Mar. 16	Mar. 30	Mar. 30	April 8	28 days.	July 20	8 lbs.
Foster	Mar. 16	Mar. 27	Mar. 30	April 6	28 days.	Aug. 16	60 lbs.
George's Late Free	Mar. 13	Mar. 30	Mar. 30	April 10	30 days.	Oct. 2	60 lbs.
Governor Garland	Mar. 22	April 1	April 5	April 14	32 days.	July 1	30 lbs.
Hale's Early	Mar. 22	April 5	April 8	April 14	30 days.	July 20	40 lbs.
Honest Abe	Mar. 16	Mar. 30	April 4	April 14	26 days.	Aug. 15	15 lbs.
Italian Dwarf	Mar. 22	Mar. 30	Mar. 30	April 6	30 days.	Sept. 20	4 fruits.
Lagrange	Mar. 22	Mar. 30	Mar. 30	April 10	30 days.	Sept. 20	6 lbs.
Late Admirable	Mar. 13	Mar. 30	Mar. 30	April 10	28 days.	Sept. 15	10 lbs.
Lovell	Mar. 22	Mar. 30	Mar. 30	April 4	28 days.	Sept. 6	60 lbs.
Morris White	Mar. 22	Mar. 30	Mar. 30	April 6	28 days.	Set no	fruit.
Mrs. Brett	Mar. 12	Mar. 24	Mar. 24	April 10	30 days.	Sept. 1	100 lbs.
Muir	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 1	20 lbs.
Picquett's Late	Mar. 13	Mar. 24	Mar. 30	April 10	30 days.	Sept. 20	20 lbs.
Royal George	Mar. 13	Mar. 27	Mar. 30	April 6	33 days.	Aug. 16	5 lbs.
Salway	Mar. 22	Mar. 30	April 5	April 10	30 days.	Sept. 8	30 lbs.
Smock's Late Free	Mar. 22	Mar. 30	April 5	April 10	30 days.	Sept. 20	40 lbs.
Stump the World	Mar. 13	Mar. 27	Mar. 30	April 6	26 days.	Sept. 20	4 lbs.
Susquehanna	Mar. 16	Mar. 30	Mar. 30	April 10	----------	Sept. 8	50 lbs.
Thissell's White	Mar. 13	Mar. 30	Mar. 30	April 8	25 days.	Sept. 15	20 lbs.
Wager	Mar. 22	Mar. 30	Mar. 30	April 10	32 days.	Sept. 1	20 lbs.
Ward's Late Free	Mar. 13	Mar. 27	Mar. 30	April 6	28 days.	Set no	fruit.
Waterloo	Mar. 22	Mar. 30	April 5	April 14	----------	July 8	8 lbs.
Wheatland	Mar. 16	Mar. 30	Mar. 30	April 10	26 days.	Sept. 1	25 lbs.
Yellow St. John	Mar. 22	Mar. 30	Mar. 30	April 10	30 days.	Aug. 16	40 lbs.

The earliest ripening peaches on the list are Governor Garland, a white-fleshed peach of fair size belonging to the semi-cling type of the Hale's Early and the well-known Briggs' May. Another excellent early peach, Jennie Worthen, not represented in the table, ripens about the same time—July 1st. All are seven days in advance of Amsden and Waterloo, a few years ago considered among the earliest.

The latest freestone listed is George's Late Free, which ripened October 2d. A variety received under the name of General Bidwell ripened October 20th, the latest peach on the Station, surpassing in this respect Garey's Hold On, Bilyeu's October, and all the clings. The true name of this variety (which is too late for the district, failing to mature before the frosts) remains to be ascertained another fruiting season.

The first blossoming began March 12th, with Mrs. Brett, a September peach, followed swiftly by some eighteen varieties. A little later, between March 16th and 22d, the rest of the peaches began to bloom. From twenty-five to thirty-two days was the total period of bloom. The very early peaches, such as Briggs' May, Amsden, and Governor Garland, did not begin to blossom till March 22d, nine or ten days later than the first bloomers. Nevertheless they took the longer period of thirty-two days to complete their blooming season. There is a suggestion of undeveloped possibilities in such facts. If Briggs' May, which began to bloom March 22d, had blossomed March 12th, with Mrs. Brett, but had matured with its own usual rate of speed, it would have ripened ten days earlier than before. Again, if blossoming with Mrs. Brett it had adopted the short blooming period of Thissell's White, and then proceeded to grow and ripen according to the usual plans of Briggs' May, it would have shortened its season seven more days. It looks as if the horticulturist could hope to have a peach as good as the early types, and not less than seventeen days earlier than any now known; either this or peaches of better quality, because blossoming earlier, and having more time to mature before the usual Briggs' May and Alexander season.

Comparative Table of Clingstone Peaches—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.	Amount.
Albright's Cling..	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 8	25 lbs.
Chinese Cling....	Mar. 22	Mar. 30	April 5	April 12	32 days.	Aug. 16	40 lbs.
California Cling..	Mar. 13	Mar. 27	Mar. 27	April 6	28 days.	Sept. 8	30 lbs.
Heath Cling	Mar. 13	Mar. 30	Mar. 30	April 6	32 days.	Aug. 12	30 lbs.
LargeWhite Cling	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 1	40 lbs.
Lemon Cling.....	Mar. 18	Mar. 27	Mar. 30	April 10	26 days.	Aug. 28	25 lbs.
McKevitt's Cling.	Mar. 13	Mar. 28	Mar. 30	April 14	30 days.	Sept. 10	20 lbs.
Nichol's Orange Cling.....	Mar. 22	April 3	April 8	April 14	30 days.	Sept. 8	10 lbs.
Newington Cling.	Mar. 13	Mar. 27	Mar. 30	April 10	30 days.	Sept. 20	40 lbs.
Oldmixon Cling..	Mar. 13	Mar. 30	Mar. 30	April 6	28 days.	Aug. 12	12 lbs.
Runyon's Orange Cling.....	Mar. 13	Mar. 27	Mar. 30	April 8	30 days.	Sept. 8	60 lbs.
Seller's Cling.....	Mar. 13	Mar. 27	Mar. 30	April 10	20 days.	Sept. 10	30 lbs.
Tuscany Cling ...	Mar. 16	Mar. 30	April 1	April 8	28 days.	Aug. 22	30 lbs.
Wilkins' Cling ...	Mar. 16	Mar. 27	Mar. 30	April 8	28 days.	Sept. 20	few fruits

Nearly all the peaches listed in the two preceding tables were entirely free from curl-leaf during the season of 1893. The only bad cases of curl-leaf were on the Large White Cling, Oldmixon Cling, Italian Dwarf, and Lagrange. A little curl-leaf, not enough to injure the crops, was

noticed on the Oldmixon Free, Crimson Beauty, and Thissell's White. No other disease was visible on fruit or trees.

Mr. Tyson recommends for the Paso Robles region the following varieties: For early sorts, Briggs' May, Alexander, Amsden, and Hale's Early. For main crop (freestone), Foster, Early Crawford, Honest Abe, Muir, Lovell, Susquehanna, Mrs. Brett, and Picquett's Late. The clingstones that have done best are the California, Albright's, Runyon's, Grover Cleveland, and Heath. The most vigorous trees in the orchard are the Mrs. Brett (freestone). Though the color is somewhat against it for commercial canning, it makes a fine looking dried fruit, and is excellent for table use.

Three seedlings produced at the Station, and fruiting for the first time last season, are worthy of note. First, a large yellow cling, ranks with the best, and the tree is of most sturdy growth. The second is a yellow freestone, much later than the Early Crawford, and of better quality than the Late Crawford. The third is somewhat of the Muir type, the best peach of its season at the Station. It is hardly necessary to say that in the multiplicity of varieties of peaches, great care will be taken to avoid introducing anything that is not a distinct improvement. There are about thirty seedling peaches still to come into bearing and to be worked over as may seem desirable.

Nectarines.—No fruit seems better adapted to the locality than the nectarine, and several new sorts are to be added to the orchard. The largest nectarine tree at the Station, five years old, is now about nine feet in spread of branches; Victoria, Early Newington, and Boston, the latter four years old, are eight feet across the branches. Five other varieties represented have made a fair growth, considering the soil. No curl-leaf appeared on any of the nine varieties except the Downton.

Comparative Table of Nectarines—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	When Ripe.
Duc de Vitry	Mar. 13	Mar. 27	April 4	April 16	Aug. 10
Hardwicke	Mar. 13	Mar. 27	April 4	April 16	Aug. 30
Early Newington	Mar. 13	Mar. 31	April 4	April 20	Aug. 25
Lord Napier	Mar. 13	Mar. 31	April 4	April 14	Aug. 21
Downton	Mar. 13	Mar. 27	April 4	April 14	Aug. 26
Victoria	Mar. 21	April 1	April 4	April 14	Sept. 1
Boston	Mar. 21	Mar. 31	April 5	April 16	Sept. 1
Boston White	Mar. 13	Mar. 31	April 5	April 20	Aug. 16
Stanwick	Mar. 21	Mar. 31	April 4	April 16	Sept. 8

According to this table most of the nectarines began to blossom March 13th, only three varieties waiting until eight days later. From ten to fourteen days were required to bring the trees into flower. The first leaf appeared from three to eight days later; in fact, every variety showed leaves on the 4th or 5th day of April, and at a date ranging from the 14th to the 20th all were in "full leaf." It would be difficult to choose nine varieties of peaches whose times of blossoming showed so little variation as is the case with these nine nectarines. Even in time of ripening the period is narrow, only from August 10th to September 8th. Doubtless the nectarine season could be extended to as great length as the peach season, by the same process of selection, and earlier varieties would have a higher commercial value.

The yield of the four- and five-year-old trees was most excellent. Early Newington bore sixty pounds of large fruit, Downton yielded thirty, Boston White forty pounds, and the other varieties sufficient to test quality. Boston fruit, yellow through to the pit, was called "poor and bitter," but may improve as the tree ages. Hardwicke, white-fleshed fruit, was of "only medium quality"; the other seven were excellent, and Victoria was particularly fine. Early Newington is a cling, the others are freestones. Varieties such as Boston White, which, nearer the coast, are often only a dull green, are of good color and firm texture at Paso Robles.

Apricots.—The collection of apricots is very fair, and has been increased this season by Spark's Mammoth, King, and several more seedlings of promise. The Hubbard, Gold Dust, and Flickinger, planted last year, have made a good growth. The largest tree in the orchard is a five-year-old Smith's Triumph, a Vacaville seedling, whose branches spread over a circle nine or ten feet across. Most of the apricots, however, are planted on very shallow soil at the edge of a swale, and have made poor growth. Those on deeper soil have done well, and there is every reason to call the apricot a marked success in the district. The following illustrative table should be studied in connection with the peach and nectarine tables:

Comparative Table of Apricots—1893.

Variety.	First Flower.	Full Flower.	First Leaf.	Full Leaf.	Blooming Season.	When Ripe.
Alberge de Montgamet	Mar. 10	Mar. 22	April 1	April 10	20 days.	July 11
Blenheim	Mar. 13	Mar. 22	April 1	April 8	20 days.	July 20
Kaisha	Mar. 13	Mar. 22	April 1	April 12	22 days.	No fruit.
Luizet	Mar. 10	Mar. 22	April 1	April 12	15 days.	July 14
Moorpark	Mar. 14	Mar. 26	April 6	April 16	20 days.	July 26
Newcastle	Mar. 13	Mar. 22	April 4	April 14	15 days.	July 6
Peach	Mar. 13	Mar. 22	April 1	April 10	15 days.	No fruit.
Royal	Mar. 11	Mar. 22	April 1	April 12	20 days.	July 18
Smith's Triumph	Mar. 13	Mar. 22	April 1	April 12	20 days.	July 24
St. Ambroise	Mar. 11	Mar. 20	April 1	April 10	15 days.	July 18
Turkey	Mar. 10	Mar. 22	April 1	April 10	15 days.	No fruit.

The earliest blossoms appeared on the Turkey, Luizet, and Montgamet (March 10th), but since Moorpark was only four days later, the beginnings were nearly the same. The range of time in the full period of bloom was much more noticeable—Turkey occupied thirteen days and Kaisha twenty-two days. The season of ripening, particularly when compared with the peaches, is unusual. The Newcastle was not fit for market until a week after Briggs' May peach, and all the eleven varieties tabulated were ripe within twenty days after July 6th. As in the case of the cherries, the climate shortens the fruit's range of season, and renders a small list of varieties necessary to cover the time between the earliest and the latest. The records of an Alameda County orchard in 1893 showed that shipments of several varieties ripening between Montgamet and Moorpark were made from July 11th to August 17th, a period of thirty-seven days. The Montgamet-Moorpark period at the Station, according to the above table, is but fifteen days, and fifteen varieties would amply cover it.

According to Mr. Tyson's notes, Luizet, Royal, Blenheim, and Smith's Triumph bore fairly well. The fruit of the last-named variety was very large, and resembled the St. Ambroise. Alberge de Montgamet, St.

Ambroise, and Moorpark bore a little fruit. All the apricots produced were of high color and flavor, free from rust or blemish.

There are twenty seedling apricots in orchard form, planted by Mr. Klee for stock, and in hopes that some might prove valuable, as the pits were very carefully chosen.

Plums and Prunes.—Most of the plums and prunes have grown fairly well, excepting those planted on the shallow soil of the southern verge of the swale, the poorest part of the orchard. Some trees here are stunted in growth and practically worthless. There is better ground, and they will be reset.

Among the varieties that have made excellent growth are Smith's Orleans, Ives' Autumn Gage, Bradshaw, German Prune, Royal Hâtive, St. Martin's Prune, Peach, and Shropshire Damson. First-class plum trees, four and five years old, on this soil, without irrigation, have made trees whose branches cover a circle of five to six feet in diameter—not more. Myrobalan seedlings of corresponding ages cover a circle of seven to eight feet across. The following varieties of similar ages have made poor growth, two feet diameter of the top being all they can show: Belle de Septembre, Satsuma, Damas Noir, Yellow Egg, Victoria, Autumn Gage, Simon, Drap d'Or d'Esperen, and Red Magnum Bonum. There are nineteen seedling plums, large Myrobalan, both yellow and red, to be top-worked hereafter.

The following table shows some details respecting the older part of the orchard:

Comparative Table of Plums and Prunes—1893.

Variety.	First Flower.	Full Flower.	First Leaf	Full Leaf.	Blooming Season.	Amount of Fruit.
Botan (Japan)	Mar. 18	Apr. 4	Apr. 4	Apr. 14	30 days.	8 pounds.
Botankio (Japan)	Mar. 18	Apr. 4	Apr. 10	Apr. 24	30 days.	----------
Burbank (Japan)	Mar. 22	Apr. 1	Apr. 4	Apr. 14	----------	*
Chabot (Japan)	Feb. 13	Feb. 27	Feb. 27	Mar. 12	27 days.	Set no fruit.
Kelsey (Japan)	Feb. 27	Mar. 10	Apr. 1	Apr. 10	40 days.	15½ pounds.
Ogon (Japan)	Feb. 14	Feb. 27	Mar. 8	Mar. 20	28 days.	Set no fruit.
Bavay's Green Gage	Apr. 14	Apr. 22	Apr. 18	Apr. 24	16 days.	25 pounds.
Bryanstone	Apr. 14	Apr. 24	Apr. 20	Apr. 30	----------	12 plums.
Coe's Golden Drop	Apr. 10	Apr. 20	Apr. 22	Apr. 30	20 days.	23 pounds.
Czar	Apr. 16	Apr. 26	Apr. 22	Apr. 30	16 days.	11 pounds.
Damson	Apr. 3	Apr. 24	Apr. 22	Apr. 30	20 days.	20 pounds.
Early Golden	Apr. 4	Apr. 16	Apr. 12	Apr. 20	20 days.	10 pounds.
Imperial Gage	----------	----------	Apr. 16	Apr. 24	----------	40 pounds.
Jefferson	Apr. 4	Apr. 14	Apr. 16	Apr. 22	22 days.	20 pounds.
Oullin's Golden	Apr. 12	Apr. 28	Apr. 16	Apr. 28	20 days.	20 pounds.
Peach	Apr. 18	Apr. 30	Apr. 18	Apr. 28	----------	6 pounds.
Précoce de Berthold	Apr. 12	Apr. 20	Apr. 18	Apr. 30	20 days.	25 pounds.
River's Early Prolific	Apr. 12	Apr. 22	Apr. 16	Apr. 22	16 days.	8 pounds.
Bulgarian Prune	----------	----------	Apr. 15	Apr. 25	----------	A few prunes.
Datte de Hongrie	----------	----------	Apr. 12	Apr. 22	----------	A few prunes.
German Prune	Apr. 12	Apr. 24	Apr. 18	Apr. 24	----------	A few prunes.

*Fruit eaten by squirrels.

Mr. Tyson's memoranda of the plum orchard contain the following: "Six varieties of the Japanese plums bore good crops. They have one advantage here over other kinds: they cling to the tree long after becoming ripe, and keep in a fair state of preservation for weeks. The tough texture of the flesh of most of the varieties makes it possible to ship them long distances. The best in quality were the Burbank and the Kelsey Japan.

"Nearly all varieties of prunes grew well last season. The French prune, Robe de Sergent, and Tragedy matured well, and would have made a fine dried prune. The 'Oregon Silver prune' is a strong, vigorous tree planted on south side of swale; the prunes, some seven or eight in number, were large and of fine flavor. The Barry prune, though not so sweet as the above, is a fine, large, blue and rich prune, a freestone, and a good bearer."

Pears.—Many of the pears are on excellent soil for this fruit, though some suffer from "hardpan." The finest trees, Flemish Beauty and Colonel Wilder, are seven feet or more in spread of boughs. Other trees that have made very satisfactory growth are the following: Madeleine, Forelle, Mount Vernon, Beurré d'Amanlis, Vicar of Winkfield, and Howell. The poor trees of the orchard of eighty-six trees are Anne Ogereau, Duchesse d'Angoulême, and Easter Beurré. About sixty varieties of pears are represented, and in a year or two the orchard will begin to make a showing. There are twenty-five fine Japanese pear seedlings. In 1893, LeConte was the first variety to leaf out at the Station (March 18th); Keifer and Clapp's Favorite came next (March 30th and 31st). Nearly all the pears began to show leaves between the 1st and 13th of April, and all were in full leaf by April 30th.

Olives.—The olive trees are planted on the north, the west, and the south sides of the tract, and are growing very well indeed. It is necessary to send only large and well-rooted olives to this district; small trees are difficult to establish. Rarer and more expensive sorts not yet in nursery are being propagated at the Central Station by budding, grafting, or inarching, according to the variety. The early frosts of the district render it probable that the crop will sometimes be lost, even when the trees are quite large. Mr. Tyson's memoranda upon olives will be found incorporated into a separate report upon the olives at all the stations.

Walnuts.—The climate is very hard on all varieties of the English walnut. Nine varieties were represented here in 1889, and only three are now alive, in spite of good cultivation. Mayette and an English seedling "have made a fair growth," and the trees are very symmetrical. Præparturiens make little growth and seem to be failing in vitality.

Chestnuts.—One of the two Italian chestnuts planted in 1889 died last summer, and the other grows very slowly. They are too near to a group of oaks, but in any case the tree is unsuited to the light soil, and could only succeed in the swale or on the southern slopes beyond.

Quinces.—The locality appears to be too dry to make good fruit without irrigation. Under thorough cultivation the trees made a small growth, but the fruit was worthless.

Mulberries.—All of the varieties of mulberries do extremely well. The slowest growing kind is the Persian, but even this variety has outgrown most of the orchard trees of the same age. It bears heavily and for a long time. The Nagasaki is much the strongest grower, and can be recommended as one of the shade and avenue trees for the district. The branches of the largest mulberry trees now cover a circle fifteen feet in diameter. At the proper season the Station can make local distributions of cuttings of several excellent varieties, such as Lhoo, Nagasaki, White, Italian, Russian, and Persian. All the mulberries root easily from cuttings, and farmers from the uplands of Monterey and San Luis Obispo counties visiting the Station in winter should secure an assortment.

Figs.—The fig problem continues to be perplexing. The varieties planted in the swale when the Station was established were frozen to the ground so many times that the attempt to maintain the entire fig avenue had to be abandoned two years ago. Some of the figs on higher ground did better, though often injured by frost, and now seem comparatively safe. The late frosts usually destroy the first crop, and early frosts injure the young wood so that the trees gain but slowly. Black Bourjassotte, Angelique, Dalmatian, and White Ischia bore a fairly good main crop. The fruit was medium in size, but of excellent quality. Pollen of the wild or Capri fig was used to impregnate the Smyrna fig, but all the fig pollen of last spring was poor, and generally failed to fructify, though used by several experienced pollinators at various places in the State. The varieties of figs lost at the Station have been replaced on less frosty ground.

THE VINEYARD.

There has been a good deal of trouble about nomenclature at this Station, owing to careless handling of cuttings sent here several years ago, but as the grapes are studied corrections are being made, and the faulty vines in the rows grafted over. The new vineyard of Persian and Italian grapes is excellent in this respect, and in a year or two all trouble in the older vineyard will be at an end. This new vineyard contains seventeen rows of twenty-five vines each, at the southwest corner of the Station tract, on sandy soil. The old vineyard, occupying about one sixth of the Station tract, the central third of the eastern half, can only be extended toward the north into the swale where the soil becomes heavier. Full reports upon the vineyards at all the Stations will be found elsewhere in this volume.

SMALL FRUITS.

The problems involved in small fruit culture on the lighter soils of the dry upland are very serious. Without irrigation, strawberries cannot be grown, and blackberries and raspberries fail for lack of enough moisture to perfect the fruit. Even if a small crop could sometimes be matured by extra cultivation and sheltering the vines, it would not be practicable for farmers on such land to grow enough for family use. Gooseberries and the new Logan Berry promise better success.

Gooseberries.—The Berkeley set about half a crop; berries good size. Downing's Prolific grew well, and bore a full crop of large berries; Champion grew well, and fruited better than Berkeley. The only care taken of the gooseberries was to shelter them from the extreme heat of the sun by cheap lath frames. The sunburn, which has ruined the gooseberry crop for several seasons, was entirely prevented. The last picking was on June 20th. Bushes made strong growth during the summer. Mr. Tyson states that the first price of the lath frames has been repaid by the crop, and the frames are extremely useful for sheltering young plants, etc. In fact, the ordinary fruit-drying tray so common on California farms is excellent for all such uses.

Logan Berry.—Again the record of this berry is remarkable. It originated in one of the moist Coast Range valleys (Santa Cruz), near the ocean, and yet when taken to the hot, dry upper Salinas, it thrives and perfects its berries. The fruit is large, of uniform size, high color, and

extremely pleasant flavor. The habit of vine growth most resembles the Black-cap raspberry; the color and flavor of the fruit are suggestive of the largest of red raspberries; the shape and texture of the berry are similar to the more solid blackberries. Mr. Tyson reports that the Logan Berry "bore a full crop." It can be recommended for testing in localities too hot and dry for red currants, raspberries, and blackberries, but, like all fruit, will respond proportionately to more generous soils and a moister climate.

SMALL CULTURES.

Cotton.—The cotton plots were planted April 19th. Four varieties of upland cotton were planted—Poor Man's Relief did much the best. The plants were small, not more than eighteen inches high, but the bolls were said by Southerners who visited the Station to be larger than they had ever seen of the same variety.

Melons, Cucumbers, and Gourds.—The region is called a "good water-melon country." The melons are not large, and late planting is necessary, but the quality is high. Last season some seeds of each variety of melon, cucumber, and gourd were sown in the open ground, and some were started early under glass, in paper boxes; but soil and atmosphere were so dry at the transplanting season, that the seeds sown in the open ground overtook and surpassed the house-grown plants. The only way to handle tender vegetables such as the melons, egg-plant, tomatoes, and peppers, and have them early in this region, is to transplant from under glass to the field before the late rains, and protect each plant, which is expensive and troublesome. It can be done on a small scale, however, for the garden. Where land is irrigated, hot-bed plants need not be put out until the nights are warm.

A dozen varieties of ornamental gourds were planted, but the seed was mixed and only five proved distinct. Seeds of the Dipper and the Nest-egg gourds are often asked for by persons who want rapidly-growing vines.

The Ispahan muskmelon, a new sort obtained by the Agricultural Department at Washington from correspondents in Persia, made a rapid growth, surpassing any other variety. Unfortunately, most of the melons cracked and decayed before ripening. The melon is large, oblong, fine-grained, and white-fleshed. Melons picked at different periods of maturity and laid away to ripen, all decayed before becoming fit to eat. If grown in some other locality, it might prove a good market variety, as the appearance is attractive.

Tomatoes.—Golden Queen, Acme, and Trophy were planted by Mr. Tyson. Late in autumn he protected the vines with lath frames, and kept them alive and growing through the following frosts: November 16th, 26°; November 11th, 27°; November 13th, 27°; November 14th, 28°. But the cold of November 18th, 19°, killed the vines.

Potatoes.—Sixteen varieties planted March 22d; no fertilizers used. Dandy, Peerless, and White Pearl yielded small crop. The climate is too hot and dry for ordinary potato culture on most of the rolling lands east of the Salinas. Mr. Tyson thinks that potatoes can be grown here by heavy applications of well-rotted stable manure, plowed in about February 1st, before planting, and a top-dressing later. Earlier planting will also be necessary.

Other Vegetables.—Long Orange carrots were very small. Blood Turnip beets a failure. Very dry for snap-beans; Black-eyed and Golden Wax bore fairly. Among garden peas, Fill Basket, Prize Taker, and Alaska bore well.

GRASSES, FORAGE PLANTS, AND CEREALS.

The experiment plots for 1893 were all laid out at the foot of the northwestern slope, but below the adobe soil. A superb collection of grains was the result, one that has not been surpassed by any season's growth at the Station. Mr. Tyson arranged small sheaves of all grains on the walls of the office, where they remained until the opening of the Midwinter Fair. The Commissioner from San Luis Obispo County, Mr. A. M. Hardie, desired this collection for the county display in the Horticultural Building, and he was allowed to use it, labeling of course, "Grown at the Experiment Station of the University of California, at Paso Robles."

Grasses, Clovers, and Forage Plants.—The grasses sown December 13, 1892, by the former foreman, Mr. Cruickshank, came up very poorly. The following species failed to germinate: Panicum bulbosum, Panicum millaceum, Lupinus (two species). The following germinated very poorly, grew feebly, and made no record: Phleum pratense, Bromus Hookerianus, Paspalium dilatatum, Gastridium australe, Festuca ovina, Festuca tenuifolia, Panicum altissimum, Trifolium hybridum, Poa arachnifera, Onobrychis sativa. The following species "started well, but died out," owing to drought and north winds: Medicago lupulina, Trifolium hybridum, Anthyllis vulneraria. Lastly, the following species did well on the new plots, better in fact than on the sandy soil on the south end of the tract: Agropyrum Japonicum, Bromis inermis, Digitaria sanguinalis, Holcus lanatus, Lolium perenne, Agrostis vulgaris, Euchlæna luxuriaris, Phlaris media, Phalaris Canariensis, Lotos tetragonalobus, and Melilotus albus.

Noteworthy in these lists is the failure of the Texas blue grass (Poa arachnifera), which has previously done so well on light soil, also of sainfoin (Onobrychis sativa). The Bokhara clover (Melilotus albus) "remained green all summer" without cultivation—a trying test—"stems three feet high." Wild canary was the most satisfactory of the grasses. Bromis inermis "continued green until very late in the season."

Wheats, Barleys, Etc.—In this district the farmers prefer to plant Propo and Red Sonora wheats. At the Station, besides these varieties, Royal Australian, Snowflake, and Chile are reported by Mr. Tyson as especially satisfactory. The following table will show the results of the cereal plots of 1893. Wheats, barleys, and oats were sown on December 9th and 10th by Mr. Cruickshank; rye sown by him December 11th·

RESULTS OF CULTURE EXPERIMENTS WITH CEREALS.

Variety.	Headed.	Cut.	Straw.	Head.	Grain per Acre.	Straw per Acre.	Observations.
Wheats.							
Cent'nial Black-Bearded	May 20	June 23	5 ft.	4 in.	1,241 lbs.	1.55 tons.	Tallest variety at Station; yields poorly, but handsome.
Winter	May 20	June 23	4 ft. 4 in.	4 in.			Resembles Centennial.
Four-rowed Sheriff	May 25	June 26	3 ft. 3 in.	3½ in.	1,530 lbs.	1.46 tons.	Kernels small, slightly shrunken.
White-Club Brenner	May 12	June 26	4 ft.	2 in.	1,663 lbs.	1.98 tons.	Dark, oblong kernel, filled fairly.
Hungarian	May 20	June 23	3 ft. 3 in.	4¾ in.	1,980 lbs.	1.50 tons.	Dark, small kernel, slightly shrunken.
Snowflake	May 16	June 23	4 ft.	5½ in.	2,270 lbs.	2.04 tons.	Very desirable sort at Station.
Champlain	May 20	June 23	3 ft. 6 in.	3½ in.	1,843 lbs.	1.58 tons.	Small, red kernel, slightly shrunken.
Egyptian	May 12	June 23	4 ft.	4 in.	1,815 lbs.	1.04 tons.	Sound, full, bright kernel.
Victoria	May 20	June 19	3 ft. 6 in.	4½ in.	1,412 lbs.	1.38 tons.	Small, dark kernel, well filled.
Pringle's Defiance	May 12	June 23	3 ft. 6 in.	4½ in.			A good variety.
Michigan	May 27	June 23	3 ft.	3½ in.	907 lbs.	1.63 tons.	Loose chaff; did poorly; kernel shrunken.
Red Sonora	May 3	June 19	3 ft. 6 in.	4 in.	2,212 lbs.	1.26 tons.	Small kernel, very plump.
Pringle's Best	May 12	June 23	4 ft.	4 in.	2,722 lbs.	2.38 tons.	Large, full, bright kernel.
Bonate	May 20	June 19	3 ft. 3 in.	3½ in.	2,042 lbs.	2.25 tons.	Kernel small, slender, dark.
Indian Winter	May 12	June 19	3 ft. 6 in.	4 in.	1,339 lbs.	1.98 tons.	Shells out too easily; a little shrunken.
Tunisian	May 12	June 23	5 ft.	3 in.	850 lbs.	1.20 tons.	Large, dark kernel, badly shrunken.
Taganrog	May 10	June 19	4 ft. 6 in.	3½ in.	1,616 lbs.	1.97 tons.	Resembles Centennial; kernel dark.
Genesee	May 16	June 19	3 ft. 8 in.	4 in.	1,815 lbs.	.59 ton.	Dark kernel.
Hallet's Pedigree	May 28	June 30	3 ft.	4½ in.	1,020 lbs.	1.81 tons.	Too late for this climate.
California Spring	May 17	June 23	3 ft. 4 in.	3 in.	3,261 lbs.	2.55 tons.	Smutted badly; otherwise did well.
Nonpareil	May 17	June 19	3 ft. 6 in.	5½ in.			A desirable variety.
Thuringian	May 20	June 23	3 ft. 8 in.	3 in.	2,297 lbs.	2.48 tons.	Kernels dark, shrunken.
Red Club or Hedgehog	May 20	June 23	3 ft.	1¾ in.	1,871 lbs.	1.62 tons.	Small red kernel, filled fairly well.
Red Bearded	May 20	June 19	3 ft. 6 in.	2½ in.	1,049 lbs.	1.17 tons.	Loose chaff; slightly shrunken.
Harris from Jasper	May 12	June 19	3 ft. 6 in.	4½ in.	1,531 lbs.	1.98 tons.	Dark kernel.
White Pearl	May 12	June 19	4 ft. 3 in.	5 in.	2,268 lbs.	1.78 tons.	Plump, bright-colored kernel; did *very* well.
White Sonora	May 17	June 23					
Indian Three-Months	May 15	June 27	4 ft.	5½ in.	2,722 lbs.	2.26 tons.	Fine, large, white kernel.
Hungarian Brenner	May 20	June 20	3 ft. 3 in.	4½ in.	1,978 lbs.	1.79 tons.	Slightly shrunken; dark.
Nicaragua	May 12	June 23	4 ft. 3 in.	3½ in.	1,815 lbs.	1.58 tons.	Small, dark kernel.
White Elama	May 20	June 23	3 ft. 6 in.	4 in.	2,013 lbs.	1.92 tons.	Kernels rather dark; filled well.
Hallet's Genealogical	May 20	June 26	3 ft. 6 in.	3 in.	1,815 lbs.	2.32 tons.	Kernels large, oblong, slightly shrunken.
Mold's White Winter	May 17	June 19	3 ft.	3 in.			A very poor variety here.
Hybrid Dettel	May 25	June 19	3 ft. 6 in.	3 in.	1,899 lbs.	2.28 tons.	Large, well-filled kernel.
Defiance	May 12	June 19	4 ft. 6 in.	4½ in.	2,325 lbs.	1.97 tons.	Appeared well here.
Hallet's Original Red	May 27	June 30	3 ft.	3 in.	1,163 lbs.	1.30 tons.	Long, dark kernel.
Diehle Mediterranean	May 19	June 19	3 ft. 6 in.	3 in.	2,404 lbs.	2.01 tons.	Matures too late.
Martin's Amber	May 25	June 26	3 ft. 6 in.	4 in.	1,815 lbs.		Inferior quality here.
Petali	May 2	June 14	4 ft.	4 in.	2,155 lbs.	1.88 tons.	Large, dark, full kernel.

Jonquil	May 2	June 19	4 ft. 6 in.	4 in.	3,062 lbs.	2.12 tons.	A fine, plump, bright kernel.
Red Sonora	May 3	June 19	3 ft. 6 in.	4 in.	2,212 lbs.	1.26 tons.	Sown much in this section.
Palestine	May 5	June 14			1,531 lbs.	1.19 tons.	Kernel oblong, dark, not very full.
Mold's Red Winter	May 25	June 30	3 ft.	3 in.	1,474 lbs.	1.81 tons.	Ripens too late.
Blue Glass	May 12	June 23	4 ft.	3 in.	1,355 lbs.	2.18 tons.	Good for show purposes.
Imperial Circassian	May 20	June 30	4 ft. 3 in.	4 in.	3,113 lbs.	2.72 tons.	Long, slim, bright, full kernel.
Diamond, or Polish	May 12	June 19	5 ft. 6 in.	5 in.	1,616 lbs.	1.63 tons.	Long head.
Russian Bearded	May 12	June 19	4 ft. 3 in.	4 in.	1,483 lbs.	1.98 tons.	Medium full, red kernel.
Greek Atlanti	May 12	June 19	4 ft. 6 in.	4 in.	1,872 lbs.	2.02 tons.	Quite plump kernels.
Frankenstein	May 20	June 30	3 ft. 6 in.	5 in.	2,694 lbs.	2.40 tons.	Dark, fine, large kernel.
Volo	May 6	June 19	4 ft. 9 in.	3 in.	1,701 lbs.	2.02 tons.	Large, dark kernel, fairly plump.
Chiddam	May 20	June 30	2 ft. 10 in.	3 in.			Loose chaff; shells too easily.
Fern or April	May 20	June 23	3 ft. 6 in.	4 in.	1,588 lbs.		Shells badly; very small kernel.
Whittington	May 12	June 19			1,128 lbs.	1.13 tons.	
Nonette Lausanne	May 12	June 23	3 ft. 6 in.	2½ in.	2,262 lbs.	1.53 tons.	Small, plump, dark kernel.
Missoyen	May 12	June 23	4 ft.	3 in.	1,928 lbs.	1.79 tons.	Half club bearded.
Oregon Big Club	May 12	June 23	3 ft. 6 in.	1¾ in.	2,382 lbs.	2.32 tons.	Smutted badly.
Touzelle	May 20	June 23	3 ft. 2 in.	4 in.	1,645 lbs.	1.95 tons.	Filled fairly well; thinned out by squirrels.
Forelle	May 20	June 23	3 ft. 6 in.	5 in.	1,531 lbs.	1.47 tons.	Kernels badly shriveled.
Yellow Noe	May 16	June 23	4 ft. 2 in.	4½ in.	2,467 lbs.	2.49 tons.	Fine, large, bright, well-filled kernel.
Clawson	May 10	June 23	4 ft. 3 in.	4 in.	3,119 lbs.	2.38 tons.	Kernels full and bright.
Imperial Circassian	May 10	June 19	4 ft. 3 in.	4 in.	2,495 lbs.	2.60 tons.	Bright colored kernel; filled well.
Chile	May 10	June 19			3,006 lbs.	1.98 tons.	Filled fairly well; some smut.
Royal Australian	May 6	June 19	4 ft. 2 in.	4 in.	2,807 lbs.	2.04 tons.	A good variety; kernel plump and bright.
Archer's Prolific	May 6	June 19	4 ft.	5 in.	3,516 lbs.	2.18 tons.	Bright, plump kernel.
Barleys.							
Early Black Two-rowed	April 17	June 5	3 ft. 3 in.	3 in.	3,233 lbs.	1.34 tons.	Filled well.
Six-rowed Brenner	May 20	June 14	3 ft.	2 in.	2,609 lbs.	1.70 tons.	A desirable sort; not too late.
Black Six-rowed	May 6	June 7	3 ft. 6 in.	3½ in.	1,892 lbs.	1.53 tons.	Fine, plump kernels.
Hallet's Pedigree Chev.	May 3	June 7	3 ft. 6 in.	5 in.	2,836 lbs.	1.47 tons.	Kernels bright and plump.
Bluish Barley	April 20	June 5	3 ft. 6 in.	3¾ in.	1,276 lbs.	.56 ton.	Plump; no hull.
Nepaul	April 20	June 5	3 ft.	3 in.	1,355 lbs.	.53 ton.	Beardless; plump.
Large Naked Two-rowed	May 3	June 5	3 ft.	4¼ in.	1,418 lbs.	.63 ton.	No hull.
Dept. Agric. No. 2	May 3	June 5	3 ft. 6 in.	4 in.	3,970 lbs.	1.50 tons.	Plump; bright blue color; No. 1 brewing.
Dept. Agric. No. 6	May 3	June 5	3 ft. 6 in.	3½ in.	3,779 lbs.	1.30 tons.	Every way desirable, as above.
Kalina	April 29	June 5	4 ft.	4½ in.	1,644 lbs.	.91 ton.	Quality, fair.
Berkeley Hybrid	April 29	June 5	3 ft. 6 in.	3 in.	1,588 lbs.	1.04 tons.	Beardless; two-rowed; plump, bright kernels.
Scotch Two-rowed	May 2	June 5	3 ft. 6 in.	5½ in.	2,062 lbs.	1.20 tons.	Chevalier type.
Italian	May 3	June 7	3 ft. 6 in.	4 in.	2,779 lbs.	1.55 tons.	
Six-Rowed Winter	May 3	June 5	3 ft. 4 in.	3 in.	1,871 lbs.	.90 ton.	Fair quality.
Carter's Prolific	May 3	June 7	3 ft. 6 in.	5 in.	2,036 lbs.	1.36 tons.	Chevalier type.
Rice or Sprat	May 17	June 14	2 ft. 10 in.	2 in.	1,588 lbs.	1.13 tons.	Ripened too late.
Chevalier	May 5	June 7	3 ft. 4 in.	5 in.	2,382 lbs.	1.30 tons.	Bright, plump; grows well here.

RESULTS OF CULTURE EXPERIMENTS WITH CEREALS—Continued.

Variety.	Headed.	Cut.	Straw.	Head.	Grain per Acre.	Straw per Acre.	Observations.
Oats.							
Gray from Houdan	June 1	June 19	3 ft.		2,042 lbs.	2.55 tons.	Best white oat grown at the Station.
Bald	May 27	June 14	4 ft.		1,531 lbs.	1.95 tons.	Hull removes easily while threshing.
Oats from Texas	May 6	June 7	4 ft.		1,873 lbs.	1.55 tons.	A good oat here; the first to ripen.
Surprise	June 1	June 14	4 ft. 6 in.		1,616 lbs.	2.29 tons.	Bright kernel; well filled.
White Bolognese	June 1	June 14	5 ft.		2,155 lbs.	2.36 tons.	Not so bright as gray oats, but did as well.
Early from Georgia	May 27	June 19	4 ft. 6 in.		1,815 lbs.	2.32 tons.	Kernel dark; filled fairly.
Canadian	May 27	June 14	4 ft. 6 in.		1,815 lbs.	1.70 tons.	Bright, well-filled kernel.
Black from Coulombieres	June 1	June 19	3 ft. 6 in.		1,361 lbs.	2.46 tons.	Very dark kernel.
Black Tartar	June 1	June 19	3 ft.		1,873 lbs.	1.49 tons.	Poor kernels.
Scotch Hopetown	June 1	June 14	4 ft. 6 in.		1,531 lbs.	2.38 tons.	Large, bright kernel, well-filled.
White Wonder	June 1	June 19	4 ft. 6 in.		2,495 lbs.	2.83 tons.	Grew little after heading out; filled well.
Early August	June 1	June 19	4 ft.		1,758 lbs.	1.75 tons.	Light-colored kernel; filled fairly.
Ryes.							
Spanish Double-bearing	May 5	June 7	4 ft. 3 in.	8½ in.	1,473 lbs.	3.11 tons.	The ryes grew about alike; no milling tests were made.
Perennial Saxon	May 2	June 30	5 ft. 3 in.	6 in.	1,815 lbs.	2.42 tons.	
Excelsior Winter	May 6	June 30	5 ft. 3 in.	6½ in.	2,319 lbs.	1.36 tons.	
Swedish Sand	May 6	June 30	5 ft.	6 in.	1,644 lbs.	1.38 tons.	
St. John's Day	May 2	June 30	5 ft. 3 in.	7 in.	2,319 lbs.	2.89 tons.	
Spelts.							
White Silesian	May 30	June 30	3 ft. 6 in.	6 in.	2,893 lbs.	.99 tons.	The spelts all grew well; the rate per acre includes the chaff, it being impossible to separate it by hand.
Blue-Bearded	May 27	June 30	3 ft. 8 in.	7 in.	2,036 lbs.	1.36 tons.	
Red Emmer	May 27	June 30	3 ft. 4 in.	6 in.	1,475 lbs.	.88 tons.	
White Emmer	May 27	June 30	3 ft. 6 in.	3½ in.	2,098 lbs.	1.26 tons.	
White-Bearded	May 27	June 30	3 ft.	6 in.	2,609 lbs.	*	
Bearded Brown	May 30	June 30	4 ft. 3 in.	3½ in.	1,134 lbs.	1.70 tons.	

* Not weighed.

The small plots which are used in testing the cereals are all prepared with care, plowed twice, harrowed, then raked smooth. Seed is drilled in; no fertilizers are used; weeds are hoed out. This will explain the high yield, calculated on areas of plots, which are usually twelve feet long by six feet wide. An examination of the table will show that in point of yield Pringle's Best, Chile, California Spring, Jonquil, and Indian Three Months far surpass the popular Sonora. The heaviest yield of oats was given by White Wonder, with White Bolognese coming next. In barleys, Department of Agriculture No. 2 and No. 6 easily lead the rest. Excelsior Winter and St. John's Day ryes are the most productive, and the old White Silesian spelt has no superior.

NOTES ON PRUNING DECIDUOUS FRUITS.

By W. H. Tyson, Foreman Southern Coast Range Station.

A practical knowledge of pruning, it seems to me, is one of the essentials of successful fruit culture, particularly in the department of deciduous fruits. As all the first-rate horticultural authorities tell us, pruning is most important, and yet, as they often warn us, and as even casual observation shows, pruning is easily carried too far, or is wrongly done. No other subject provokes more heated or more frequent discussions at conventions of orchardists, or brings out so many irreconcilable views. Nor is this due entirely to local differences of soil or climate. Fruit-growers of the same little neighborhood very often entertain widely different views in regard to some of the leading principles and many of the details of the operation. One thing, at least, seems certain, that it takes years of practical experience, added to some degree of aptitude and some knowledge of the principles of plant growth, for any one to become a really competent tree-pruner.

Theory and observation alone, though necessary, and indeed invaluable, cannot make one proficient in the handicraft, unless accompanied by much practice with saw and pruning shears. My own experience dates from the year 1877, when, in Alameda County, I planted a small orchard, the annual pruning of which I still direct. Nor need it be taken as evidence of stupidity when I add that though I have been pruning more or less every season since then, I find that continued practice still suggests improvements. The living tree is more and more interesting to me, and its requirements become more and more individual. I am still a student in the schools of pruning.

It is not possible to prune a tree after an ideal model, and then to stereotype that form, in all its details, so as to reproduce it exactly in every successive operation over an entire orchard. One cannot even have an ideally pruned tree as representative of each species of fruit tree. Pruning is not so simple as that, nor so mechanically learned and taught. Different species of trees require different details in pruning; so do different varieties of the same species; so do different individuals of the same variety; even the same trees will require different management as they grow older.

As a rule, the deciduous fruit trees have two different habits of growth: the upright and the spreading. Peaches and apricots are good types

of upright growers; most of the apples and many pears are spreading, though some of the most upright growers among deciduous fruits are to be found among the pears. The growth of the tree when small is often greatly changed as it becomes mature. In pruning one should endeavor as much as possible to conform to the natural habits of the tree, modifying those habits no more than is necessary to secure the aim of all pruning—better fruit production. Here, at the Experiment Station, I have adopted the oval and the round-head systems of shaping fruit trees, always remembering that in this hot, dry climate, terminal buds must be left low down, and around the tree, in both forms.

It is now generally conceded by California fruit-growers of experience that low heads are much the best. Here, at Paso Robles, there is little or no choice in the matter, as trees with long trunks would suffer greatly from sunburn and borers. In this district, and in all similar localities, I advise even lower heads than are usually seen in orchards—as low, in fact, as trees can be grown, and yet close cultivation practiced. Every foot added to the length of the trunk is also a foot added to the fruit-grower's spraying hose and to his picking ladders.

If a tree is to continue in health and vigor, it must be kept growing. Rainfall and thorough cultivation do their parts, but much depends on the judicious heading back and thinning of branches and leaders. When the soil is poor, the need of severe pruning increases. Trees that grow wood without irrigation on the thin mesa land of this district will grow good fruit if properly managed; in fact, if too great a quantity of fruit is not allowed, the quality of the crop on such land is of the best. As every fruit-grower knows, there are compensations in these things.

Leaving the general aspect, I will now proceed to give in detail the system of pruning as done by me at the Experiment Station, and as recommended by me for similar soils and climates. It will not be out of place, I hope, for me to say a few words in regard to the condition in which I found the experiment orchard at the time of taking possession, in the spring of 1893. As a rule, the trees had been started low enough, but previous pruning had been too uniform. All varieties of fruit, of every species, had been headed back to equal length, and the branches, in my opinion, had been left altogether too close to admit sufficient light and air. Even almond trees had formed no exception to this system. Some of them that had not yet been pruned, I let remain without cutting back, and they are now fine, stocky trees, full of fruit buds and capable of supporting all the nuts they can possibly carry. The pruned almonds made only long, slender, close-set growths of leaders, most of which will have to be entirely cut away this winter (1893–94), leaving the remaining branches of slender growth, and thus delaying full fruitage.

Almonds.—Almond trees are rapid growers. In most parts of California they grow too fast, hence I believe we should not prune any longer than is necessary to shape the tree, for as long as a tree is cut back heavily, so long will it continue to grow wood. As soon as a tree is old enough, it will produce fruit spurs, if not headed back. Having noted the very satisfactory result of letting some almond trees go unpruned last spring in order to obtain fruit buds, I venture to say that there is no need to head back the almond in this section after the fourth year. The only pruning required is to remove interlocking branches and maintain the general shapeliness of the tree. In Alameda County I used to prune almonds until after the sixth year, for trees grew so rap-

idly on the valley lands there, that the trunk of the tree usually needed strengthening to enable it to support the branches and leaves. When a stocky trunk was secured, the tree was allowed to develop naturally, with light pruning thereafter.

Apricots.—I have pruned apricots at the Station grounds on the round-head system, cutting the leaders back for about two thirds of their length. The apricot tree splits down much easier than other deciduous fruit trees, except, perhaps, the fig. I therefore prune so as to avoid as much as possible those dangerous forks where two branches start from the same point and at the same angle.

It has been observed that the brightest, cleanest, and best flavored apricots grow in the shade of the leaves, on spurs and short laterals which extend from wood of two years' growth. I therefore leave only a few, well-chosen leaders, but I let the spurs extend down to the forks of the lowest branches, only removing from year to year those that have perished. I notice here, at the Station, that the small twigs and fruit spurs of the apricots die back to a considerable degree, but still not as much as in Alameda County, where one had to cut back to some extent every year, giving the bark a chance to heal over, and making room for new fruit spurs. The summer heat is much less intense in Alameda County than here, and the fruit-growers there, and throughout the Santa Clara Valley generally, are able to prune after the California vase-shaped system, running the branches up obliquely from the base, with a slightly convex top. Here, as I have said, the head must be more compact.

Prunes.—This district is planting more prunes, and seems well adapted to this fruit. In such places where the summer temperature often goes above 100° Fahr., I feel sure that prune trees need to be cut back without hesitation year after year. The non-pruning method, as advocated, and often practiced, in the coast districts, will not do here; indeed, I am not certain that it ever does well very long in any one place. Pruned back, and kept small, the tree will carry all the fruit it should, and the quality of the fruit will be superior. I should prune trees of Prune d'Agen every year, confining the fruit spurs to the main branches of the tree, and cutting the leaders back to about two thirds of their original length, with the side branches cut somewhat shorter. In planting a new prune orchard here, I should start the branches only six or eight inches from the ground. Most varieties of plum and prune easily take the round-head form, but a few, of strong upright growth, do best with the oval system. The fruit spurs are on short laterals of old wood.

Apples.—The leaders of the apple trees were usually pruned back fully three fourths this season, leaving laterals well down upon, and around, the sides of the trees. A strong, stocky apple tree is to be aimed at in pruning, for the strain is heavy on the tree in seasons of large crops. The apple bears on spurs and short twigs about the main body of the tree, and carries its crop so well distributed that comparatively little thinning is needed. The small laterals often bear fruit first on young trees; after the trees are in full bearing, the bearing points can readily be confined to the spurs alone.

Pears.—The pear is most suitably pruned with either a round or an oval head, in this climate. That much-praised form, the solid pyramidal, valuable no doubt in moister climates, is as much out of place here as

the espalier. The pear is a heavy fruit, and size and form are important to its usefulness; hence short, stocky growth of the tree is especially necessary. While pruning after something of the same general scheme as with the apples, I do not head back so much, because of the more upright habit of the pear. Like the apple, this fruit bears on spurs and short laterals, and as in the case of the apples, laterals are to be left until sufficient spurs are developed. Some varieties of pears, and a few of apples, bear in clusters. The fruit buds of these can easily be found, and the system of pruning modified so as to save them.

Cherries.—In cherry pruning, the whole field is peculiarly open to discussion. Some successful growers head back the tree year after year; others stop this pruning after the fifth or sixth year. My own experience leads me to approve the latter method. I have indeed obtained more fruit in pounds from trees cut back every year, but it was at the expense of size, quality, and consequent price. Undoubtedly, also, the exhaustion of the soil was greater, as the trees had to make wood as well as fruit. Still more convincing to my mind was the fact that trees so headed back bled much more gum than those that were allowed more freedom of growth. Cherry culture is still a problem in this district, but I have pruned less severely this winter, in the hope of securing better tops. One should avoid too early pruning of cherries, as it increases the tendency to die back from the cuts. Prune when the buds begin to expand, and the wounds will heal faster. Cherries bear on spurs which grow in clusters the entire length of the branch, on wood of more than one year's growth.

Peaches.—I have found that peaches require great care in pruning, and all the skill one can command. The round, low head that suits the peach here, makes cultivation more difficult, but amply repays the trouble. When a peach tree comes to bearing age, it requires individual study of the bearing buds and laterals. If these are abundant, one can cut off half or two thirds of the new wood; if few, the pruning must be longer to make room for the formation of new fruit buds. It often happens that a little work with pruning shears—cutting off laterals—saves much labor of thinning fruit afterwards, but this is a delicate and difficult operation, and late frosts may make one wish he had left all the fruit spurs on the tree. The longer laterals can be cut back, the dead twigs taken out, and the tree kept well open to the sunlight. Since peaches bear on new wood, it is necessary to keep the tree growing by heading back from time to time, thus renewing the top every few years.

These brief notes upon the pruning of the deciduous fruits at Paso Robles should be studied in connection with the general report upon the Station and the climatic table, which serve further to illustrate the peculiarities of the district. In conclusion: If one will study, while pruning, the objects he wishes to attain, such as symmetry of tree, convenience of cultivation, vigor and strength of trunk and branches, quantity and quality of fruit, and ease of gathering it, without having too many theories of "how to prune," he can grow an orchard pleasing to the sight and gratifying in results.

D. SAN JOAQUIN VALLEY STATION.

One mile southeast of Tulare City, Tulare County.

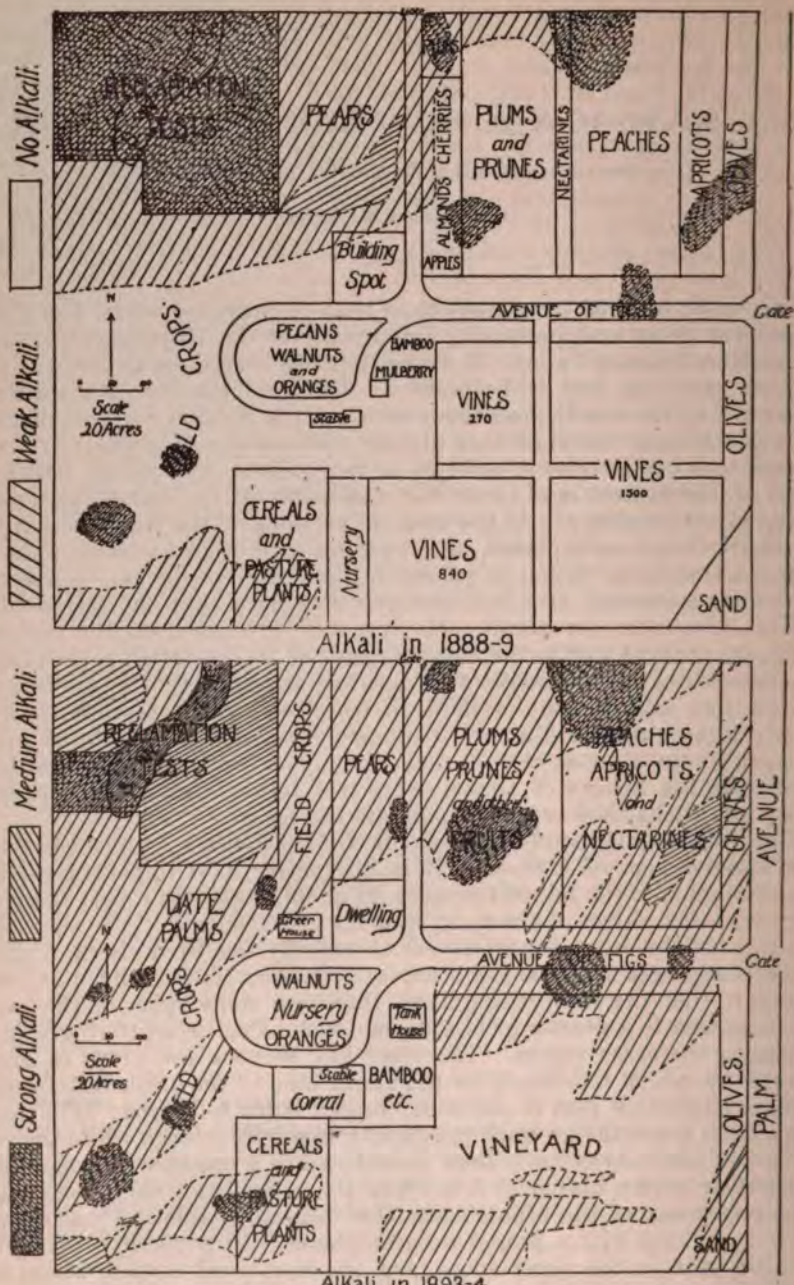
By CHARLES H. SHINN.

The work of 1893, even more than that of previous years, has illustrated the great and increasing importance of the Experiment Station of the San Joaquin Valley. Nothing that has been done there up to the present time has had to be undone. The land has been studied with reference to the alkali problems ever since the Station was established. An orchard and vineyard were planted without any gypsum treatment, on portions of the tract so selected as to represent some of the best and some of the poorest land (from the standpoint of the immediate horticultural availability). As the trees on portions of the tract succumbed to alkali, they were replaced, in most cases with other varieties, so as to give further test. Upon a second failure, the conclusion, supported whenever necessary by a soil analysis, has been that the soil needed special treatment for alkali. Having thus produced, on the orchard tract, an orchard that is the natural result of the extremely unfavorable conditions, we are gradually transforming it, and building up, tree by tree, a new and healthy orchard, in which every tree represents care, forethought, study, and labor. The mass of accumulated material upon the alkali problem at this Station, includes, therefore, complete data upon the life history of almost every tree in the orchard, and in fact every plant that has ever been put into the soil.

The first detailed study made upon this Station was published in the combined report of 1888–89. It is instructive, and important to the consideration of the following pages, to quote from this report the view that was then taken of the tract and its management: "The southeast quarter of the tract (of 20 acres) is entirely free from alkali, while a body of strongly alkaline soil occupies about one half of the northwest quarter. On the intervening land there are some spots of the same impregnated to a greater or less degree, such as occur scatteringly elsewhere in the same region. The tract has borne a few crops of grain heretofore, which failed only on the alkali land of the northwest corner." Again, in another part of the same report, is the following: "The vines have been given the grounds practically free from alkali, while the rest of the culture plants have been distributed in a measure in accordance with their known ability to flourish in the presence of obnoxious salts. The treatment of the alkali spots that became visible last season (the winter of 1888) with a proper dose of plaster will probably obviate all trouble save in the worst spots near the northwest corner, where the special experiment of reclamation will be made."

In absolute accordance with these views was the chart of the Station tract published in the above report, and reproduced here.

But after 1889, and until now, there has been a steady rise of alkali



Comparative chart showing rise of alkali during five years.
SAN JOAQUIN VALLEY STATION.

in the soil, and the problems connected with its treatment have therefore become more and more difficult. This corresponds closely to the principles laid down in the University Bulletin No. 83, and in similar publications of the Central Experiment Station, both in bulletins and in pamphlets. A map made in the summer of 1893, five years later than the previous chart, amply illustrates the nature and extent of this change. Light alkali, wherever not treated, has grown worse; alkali has appeared where in 1888 there was little or no sign of its presence. In the apple orchard, for instance, my predecessor, Mr. Klee, a very careful observer, stated in 1888–9: "In planting these, the alkaline spots were almost totally avoided, soil of this character being considered unfit for apples. The growth of the forty varieties planted has been very fair." But, as noted in the separate report on apples, a portion of the orchard is a failure from excessive alkali, and nearly all the trees have suffered. The only reasonable explanation is that there has been an increase in the amount of alkali at or near the surface of the soil. The lower map will repay careful study in connection with the preceding one. Taken together, they outline the problems of reclamation involved in the work of the Station.

Climate.—Besides the light rainfall of the district, the temperature report is unusual for the Station, in that the minimum is higher than since the Station was established. The following comparative table is compiled from the monthly reports of observations:

Tulare Temperature Report for the Fiscal Year 1892–93.

	Daily Mean.	Mean Daily Maximum.	Mean Daily Minimum.	Mean Daily Range.	Extreme Maximum (with Date).	Extreme Minimum (with Date).
1892—July	81.77	106.06	57.48	48.58	118.....3	52.....14
Aug.	82.61	106.90	58.32	47.58	118.....1, 17, 18	52.....9, 11
Sept.	75.23	98.20	52.26	45.94	112.....8	48.....18 to 24
Oct.	64.38	82.96	45.80	37.16	98.....4	32.....16
Nov.	57.83	78.20	37.46	40.74	90.....4, 11	30.....15, 17, 20
Dec.	49.90	61.16	38.64	22.52	78.....25	24.....16, 17
1893—Jan.	45.48	54.77	36.19	18.58	76.....15	28.....21, 25
Feb.	50.75	65.07	36.43	28.64	82.....21	28.....27
Mar.	54.58	67.48	41.67	25.81	98.....28	32.....1, 10, 12, 13, 14
Apr.	59.20	77.64	40.80	36.84	96.....21	32.....7, 8, 13
May	68.61	89.35	47.87	41.48	104.....11	42.....1, 25
June	74.93	97.33	52.53	44.80	110.....4	46.....12, 13, 14

Appearance of Station.—The general appearance of the Station has decidedly improved during 1894. Those orchard trees that have been well established bore heavily, and in most cases the fruit was of fine appearance and quality. The vineyard exhibited great gains. Corn, sorghum, and many other small cultures were excellent. The Station, despite its disadvantages, produced more than enough hay to supply the horses. The trees near the dwelling and some of the avenue figs have made a notable growth. A new tank-house and tank were built during the summer of 1893 and water piped to the dwelling. The buildings have also been repainted. Everything has been kept in a very

creditable condition of neatness. The Patron, Mr. A. J. Pillsbury, has shown an intelligent interest in the Station, and in the problems presented there, and the number of visitors from the better class of farmers is greatly increasing.

THE ORCHARD.

The orchard of 1893 is much the same as that of 1892, except that its good and its evil are more strongly marked. All the planting done in the past winter was with especial reference to the alkali, and its persistent treatment with gypsum before and after planting.

The method adopted for this special gypsum treatment is worthy of notice. After the holes are dug (rather larger than usual in orchard planting on good soil) and the tree is ready to set, a thin layer of gypsum is put in the bottom of the hole. Gypsum is mixed with the earth in filling in around the roots to within three inches of the surface. Mr. Forrer, the foreman of the Station, then takes an old fruit can that is cut open on one side, places it about the trunk of the tree, fills with mingled earth and gypsum around the outside of the can, and finally fills the space inside with pure gypsum. This amply protects the collar of the tree, where the alkali does most injury. Five pounds of gypsum, costing from 2 to 4 cents, at present prices of gypsum, are sufficient for a tree. In aiding trees already planted to withstand the enemy, it is often found best to make a shallow basin about the collar and larger roots, and place several pounds of gypsum therein.

On some of the land planted to trees in the above manner last winter, three successive settings of trees on different stocks have been killed by alkali, which has proved too strong for peach, almond, plum, and pear roots. On the same plot, barley sowed for a test fails to germinate on account of the alkali. The present local treatment with gypsum is therefore especially important. Besides the use of gypsum near the tree, as outlined, the entire surface of the orchard and vineyard is to receive a top dressing before the spring rains are over, and the amount of this will be noted hereafter, this report carrying operations only to the end of December, 1893. This broadcast use of gypsum is essential to success, as the small amount used about the tree will soon be dissolved and wash into the surrounding soil. There are already many spots in the orchard where barley will now grow, and others, as stated, where no crops will survive. By a uniform use of gypsum, the general grade of the whole tract is being improved, and the worst spots can receive special treatment afterward.

Before leaving the general subject, it may be well to note further that in planting trees in soil that contains any dangerous quantity of alkali, those places where the bark on the roots or collar is broken are peculiarly sensitive, just as alkali would be more severe upon a human hand if the skin were broken. Protection with grafting wax, oiled cloth or oiled paper is useful in such cases. The ends of the larger roots, after trimming smooth, should be treated in the same manner. The new roots that start are often killed by alkali in solution in the water they take up. Sometimes a tree that has been four or five years in strong alkali soil has never been able to make any more roots than it had when first planted. But if temporary protection can keep a tree in health until the roots have gone deeper the chance of success is

increased, as the proportion of alkali in each cubic foot of soil usually becomes less as we descend.

Apples.—A glance at the charts will show where the apples have been planted—in the southwest corner of the main orchard block. Forty varieties, as noted previously, were planted when the orchard was first established. Nine or ten of these perished, were replaced, and others added, so that now we have some fifty varieties represented. Those which blossomed appear in the following table, compiled by Mr. Julius Forrer, foreman of the Station:

Statistics of the Apple Orchard—1893.

Name.	In Bloom.	In Leaf.	Fruit, Etc.
Keswick Codlin	April 4	April 4	Fruit kept from July 27 to August 17th.
Missouri Pippin	April 10	April 10	12 apples; kept till Jan. 7th, 1894.
Mountain Beauty	April 4	April 4	No fruit set.
Red Astrachan	Mar. 25	Mar. 25	No fruit set.
Red Bietigheimer	April 4	April 6	No fruit set.
Red Winter Pearmain	April 9	April 10	10 apples; gath'd Oct.23; kept till Jan. 7th.
Violet	April 4	April 4	No fruit set.
Wealthy	April 4	April 4	Apples kept till Sept. 10th.
White Winter Pearmain	April 9	April 10	No fruit set.
Whitney's Crab	April 6	April 6	No fruit set.

The varieties of apple that were planted only in the winter of 1892–93 were Cook's Seedling, Ingram, Wytha, Lankford, Gravenstein, and Hyslop Crab.

Those varieties that have no bloom, by reason of the alkaline soil in which they barely keep alive, are Sonoma, Pewaukee, Hoover, and Marshall's Seedling. Some others, including Alexander, Yellow Bellflower, Stump, Arkansas Black, Jonathan, Bledsoe, Loy, and Shannon, gave no blossoms, but may do so another season. Charlottenthaler has succumbed to alkali during the past year. The time of leafage was noted in the case of all varieties not blooming, but it can be fairly doubted whether it was normal in any case where the amount of alkali was sufficient to influence the growth of the tree. The eleven varieties tabulated, all fairly normal, were in full leafage (average of the eleven) on the 4th and 5th of April; but the average date of leafage of twenty-four varieties that did not bloom was April 8th. A comparison of the dates of bloom at the other stations justifies the conclusion that the *alkaline soils tend to delay the blooming period;* quite contrary to the behavior of trees in too dry or stony soils, where they always blossom earlier in the season, and often at an earlier age than on more moist or heavier soils.

Returning to a consideration of the table, Red Astrachan blossomed the earliest of all, blooming March 25th; White Winter Pearmain, March 27th; the latest were Red Winter Pearmain, April 9th, and Missouri Pippin, April 10th. This is practically identical in point of beginning, with the season at Paso Robles, but at the latter station the blossoming season of the orchard, taken as a whole, appears to last ten days longer. The separate varieties, however, appear to occupy much the same relative position, if we disregard those varieties that grow in the stronger alkali soils, and this is evidence of the approximate correctness of the observations taken.

Apricots.—Only a few varieties of the Royal type bore any fruit, and that was stolen. The varieties that blossomed are represented in the following table:

Statistics of the Apricot Orchard—1893.

Name.	In Bloom.	In Leaf.
Alberge de Montgamet	March 15	April 4
Beauge	March 18	April 8
Boulbon	March 26	April 6
Breda	March 20	April 6
De Coulorge	March 20	April 8
Hemskirk	March 20	April 4
Kaisha	March 25	April 8
Large Early	March 15	April 4
Large Early Montgamet	March 20	April 4
Long Red	March 20	April 6
Musch-Musch	April 4	April 10
Oullin's Early	March 20	April 6
Pringle	March 25	April 6
Red Masculine	March 11	April 8
Routier's Peach	March 15	April 4
Royal	March 15	March 24
Russian	April 4	March 10
St. Ambroise	March 11	March 4

The earliest-blooming variety is the Alberge de Montgamet; not until five days later, the Royal, Large Early, and Routier's Peach are in bloom. The small and much earlier-fruiting Pringle blossoms much later, on March 25th, with Kaisha. The hardy Russian and Musch-Musch do not blossom till April 4th, and this may be said to close the blossoming season of twenty-five days. The season of bloom appears somewhat longer than at Paso Robles Station, and it remains to be seen whether or not the fruiting season is also longer.

The apricots that failed to bloom in 1893 are the following: Moorpark, Peach, Sardinian, Smith's Triumph, Canino Grosso, and Viard. Trees newly planted were Gooley's Seedling and Flickinger. As a rule, the apricots have made better growth during 1893 than in 1892, owing to the liberal use of gypsum close to the trunks of the smaller and the newly planted trees.

Almonds.—Bidwell Mammoth, a giant hard-shell, is bearing somewhat. Ten of the leading varieties of almonds were planted here five years ago, and others have been added; but the effects of alkali are very evident, and more than half of the orchard has succumbed to the enemy. The remaining sorts are Bidwell's Mammoth, which bloomed February 26th; Harriott's Seedling, February 15th; and I X L, February 24th. The earliest to show leaves was Harriott's Seedling, February 24th, and all the others were in leaf by March 6th.

Nectarines.—The record continues to be fairly good, though there is room for great gain by the use of gypsum about the trees. Mr. Forrer reports upon ten varieties, all of which bore fruit. Hardwicke was in bloom March 15th, in leaf March 27th; Stanwick, Downton, Victoria, and Early Newington bloomed March 20th, and were in full leaf between April 4th and 6th. Early Violet, Boston, and Lord Napier bloomed March 25th and were in full leaf about with the rest. The fruit of all was of good quality and of fair size, and all were ripe during the same week—in the middle of August. Evidently the nectarine season is shorter in this district than in the coast regions. As the ten varieties

listed cover nearly all in cultivation (the nectarine being a somewhat neglected fruit, not yet taken up by many specialists), the season could hardly be lengthened except by adding a variety like Hunt's Tawny, for very early, and Red Roman and Late Melting for last crop.

Peaches.—Half of the peach orchard is in excellent condition; the rest continues to be seriously affected by alkali. In tabulating the blossoming period, etc., it must be remembered that alkali affects all the trees in proportion to its strength. Strong alkali soil is colder, and blossoms and leaves often come out five or six days later on such soils, as is shown in cases where trees of the same variety are planted in different parts of the tract. The following table is compiled from notes taken by Mr. Forrer:

Observations on Peach Growth—1893.

Name.	In Bloom.	In Leaf.	Ripe.
Beer's Smock	March 25	April 6	Sept. 15
Belle Douay	March 24	April 8	August 6
Belle de la Croix	March 27	April 6	No fruit.
Bilyeu's Late	March 27	April 6	No fruit.
Bonanza	March 15	April 27	No fruit.
Brandywine	March 15	April 6	Sept. 10
Briggs' May	March 24	April 6	No fruit.
Canada Cling	March 15	March 27	Sept. 4
Chinese Cling	March 15	March 27	Sept. 6
Dr. Hogg	March 25	April 6	August 6
Early Alfred	March 25	April 4	No fruit.
Ford's Improved	March 15	March 27	No fruit.
George's Late	March 20	March 4	No fruit.
Golden Cling	March 20	April 6	No fruit.
Grosse Mignonne	March 25	April 4	No fruit.
Hale's Early	March 20	April 4	August 10
Henrietta	March 24	April 4	No fruit.
Jennie Worthen	March 24	April 8	No fruit.
La France	March 15	April 6	Sept. 4
Large Early York	March 27	April 6	Sept. 12
Lemon Cling	March 20	April 6	No fruit.
Lemon Cling (on alkali)	March 25	April 6	No fruit.
Lovell	March 15	March 27	Sept. 6
Mary's Choice	March 15	March 27	No fruit.
Mountain Rose	March 27	April 6	No fruit.
Newhall	March 18	March 27	No fruit.
Nichols' Orange	March 15	March 27	No fruit.
Noblesse	March 15	April 4	Sept. 10
Oldmixon Cling	March 15	March 27	October 1
Peen-to	Feb. 26	March 7	No fruit.
Picquett's Late	March 27	April 6	October 1
Prevost	March 25	April 4	August 25
Richmond	March 27	April 6	No fruit.
Runyon's Orange	March 15	April 4	No fruit.
Salway	March 15	March 27	October 13
Schumaker	March 15	March 27	No fruit.
Smock's Late Free	March 27	April 6	No fruit.
Stump the World	March 25	April 6	No fruit.
Susquehanna	March 20	April 4	Sept. 1
Ward's Late Free	March 20	April 6	No fruit.
Waterloo	March 20	April 4	No fruit.
Wheatland	March 20	April 4	Sept. 1
Wilkins' Cling	March 15	March 27	No fruit.
Wonderful	March 20	April 6	Sept. 21
Yellow St. John	March 15	March 25	No fruit.
Yellow Tuscany Cling	March 15	March 25	No fruit.

In all the above list the peaches are reported to have bloomed from the date first mentioned till the leaves came out. The earliest of all is, of course, the Chinese flat peach, Peen-to, or saucer, blooming February

26th. No other variety showed flowers until March 15th, or seventeen days later; but no less than fifteen varieties out of the forty-eight tabulated burst into bloom on that day. The blossoming closed March 27th, with six varieties. Leaving out the Peen-to, the main blooming season of some sixty varieties at the Station is within the last two weeks of March, and the period of leafage extends to the second week of April.

According to Mr. P. J. Berckmans, of Augusta, Ga., the Peen-to peach blooms in Georgia in January, and it does the same in Alameda County in California. The tree itself is very hardy, but late frosts often destroy the blossoms. It bears heavily about one year in three at Niles. The lateness of bloom for this variety at Tulare City (February 26th) is remarkable, and on this account it may have a chance of fruiting. All the varieties of the interesting Peen-to type deserve more extended planting, on account of the early season at which the fruit ripens. In Florida Peen-to peaches are often ripe on the 1st of April. The newer sorts, as described by Mr. Berckmans, who grew the first "saucer peaches" in America, include the following: Angel, Arlington, Bidwell's Early, Bidwell's Late, June Beauty, Red Ceylon, and Waldo.

At Tulare City, as at Paso Robles, the peach season is shorter than in many mountain or foothill districts. When Hale's Early does not ripen till August 10th, and Salway October 13th, there must be nearly three weeks' compression in the possible range of varieties. Unless the Peen-to type succeeds, there can be no ripe peaches in this district earlier than the middle of July, even in very favorable years. Necessarily this fact reduces the number of essential varieties, both for home and market purposes. The weeding-out process is of vital importance here.

Pears.—As explained in last year's report, the pear orchard certainly shows the most striking exhibition of the effects of strong alkali. It is a common misconception that pears will succeed on the worst of alkali soils, just as one hears that beets will reclaim any such soil by taking up the injurious salts. Emphasis must again be put upon the fact that what we call "strong alkali" soils at the Tulare Station, are soils in which the percentage of alkaline salts is something like 1.0 per cent or over—soils on which no crop will grow, and in which no seeds can germinate. On a soil less strong in alkali, beets can indeed be grown after a fashion, and trees of tough bark and strong texture, such as the pear, may indeed grow with difficulty. As the alkali decreases, better specimen trees are produced, until the normal orchard is reached, when it will be found that ordinary hay and grain crops do well there, though not all the fruits. A small amount of alkali does no injury to the pear; all that the tree can assimilate goes to growth and fruit, but beyond that we should theoretically expect checked growth, and disease. It is possible that the pear orchard may be planted on land too strong in alkali for apples, peaches, almonds, and apricots, but it is not possible for it to thrive on land where grain crops do not prosper.

The following table contains all the varieties that fruited at the Station in 1893:

URBANISTE PEAR on Alkali. BEURRE D'AMALIS, on Weak Alkali.

Pears 5 years old on Alkali Soil.

Statistics of the Pear Orchard—1893.

Variety.	In Bloom.	In Leaf.	Crop.
Bartlett	Mar. 25	April 4	Sept. 20; kept till Oct. 1; av. weight, 10 oz.
Beurré Clairgeau	Mar. 27	April 4	Sept. 20; kept till Dec. 25; av. w'ght, 1 lb. 7 oz.
Beurré d'Amanlis	Mar. 27	April 4	Sept. 12; kept till Oct. 10; av. weight, 14 oz.
Beurré Gris d'Hiver Nouveau	April 4	April 4	Nov. 7; kept till Jan. 7; av. weight, 1 lb.
Dearborn Seedling	Mar. 27	April 5	Aug. 15; kept till Aug. 25.
Duchess d'Angoulême	April 4	April 4	Sept. 25; av. weight, 1 lb. 7 oz.
Easter Beurré	Mar. 27	April 5	Nov. 7; kept till Jan. 7; av. weight, 1 lb. 2 oz.
Le Conte	Mar. 27	Mar. 27	Sept. 24; kept till Oct. 10; av. weight, 9 oz.
Louise Bonne de Jersey	April 4	April 1	Oct. 5; small, poor, not kept.
Mount Vernon	Mar. 27	April 3	Nov. 7; kept till Dec. 27; av. weight, 1 lb.
P. Barry	Mar. 27	April 4	Sept. 24; kept till Dec. 20; av. weight, 13 oz.
Swan's Orange	April 4	April 4	Sept. 24; kept till Oct. 1; av. weight, 9 oz.
White Doyenne	April 4	April 4	Sept. 20; kept till Oct. 1; av. weight, 10 oz.

Some items in this table go far to illustrate the immense diversity of climate in California. Beurré Clairgeau keeping till December 25th without extra precaution, is certainly a surprise; so is Beurré Gris in January with Easter Beurré; in most places it is decidedly an autumn pear. White Doyenne and Dearborn's Seedling ripen about as one would expect, but Mount Vernon keeps five or six weeks longer than usual with that variety, and the October Bartlett completes the suggestion that this district is admirably adapted to the very late pears, of which several new varieties not yet in the nurseries have been originated during the last few years.

The pear orchard now contains sixty-five varieties. During the winter of 1893, a row of Le Conte pears was planted on the east side of the avenue, between the pear orchard and the main orchard. This row extends through several grades of alkali soil, and will give a desired test of comparative growths of the same variety. Eventually, such trees as can be made to flourish under these conditions, will be top-worked to new varieties.

Plums and Prunes.—In 1888–89, a collection of seventy-five varieties of plums and prunes was planted here; nearly all were on Myrobalan stock, but these have all died from the alkali. The Myrobalan stock certainly stands light alkali soils quite well. The Mariana tree noted last year continues to thrive better than the Myrobalan, and will be tested as a stock in such locations. Unfortunately, trees on Mariana roots, ordered for last winter's planting, failed to come to hand, and it will take another year to obtain them.

Eighty-two varieties are now represented in the orchard, some planted in the winter of 1892, others of two, three, four, and five years of age. The varieties bearing last season number thirty-one, and are retabulated below:

Statistics of the Plum Orchard—1893.

Name.	In Bloom.	In Leaf.	Crop Ripened.
Bavay's Green Gage	March 27	April 10	Oct. 10
Belle de Septembre	April 4	April 14	Oct. 13
Botan	March 15	April 6	Aug. 16
Bryanstone Gage	March 25	April 4	Sept. 10
Cherry	Feb. 25	March 15	Aug. 18
Columbia	March 25	April 4	Sept. 16
Czar	March 11	April 4	Aug. 6
Damson	April 1	April 10	Sept. 25
Duane's Purple	March 27	April 6	Aug. 6
Early Golden	March 27	April 7	Aug. 25
German	March 25	April 4	Oct. 6
Guthrie's Late	March 25	April 4	Sept. 6
Imperial Gage	April 4	April 10	Sept. 15
Judson	April 4	April 10	Oct. 4
McLaughlin	March 25	April 4	Sept. 6
Perdrignon Blanc	April 4	April 14	Sept. 30
Petite d'Agen	March 25	April 4	Oct. 16
Pond's Seedling (Grosse Prune d'Agen)	April 4	April 10	Sept. 25
Prince Englebert	April 3	April 10	Sept. 15
Prince of Wales	March 25	April 4	Sept. 6
Robe de Sergent	April 4	April 10	Sept. 28
Shropshire Damson	April 4	April 10	Sept. 10
Silver Prune	April 4	April 6	Sept. 28
St. Lawrence	March 27	April 6	Oct. 10
Victoria	April 4	April 10	Oct. 1
Wangenheim	April 2	April 8	Sept. 15
Yellow Gage	March 25	April 4	Aug. 20
Yellow Magnum Bonum	April 3	April 10	Sept. 10

CEREALS AND SMALL CULTURES.

Only a small collection of selected cereals was grown in the spring of 1893, owing to the dryness of the season and the fact that so many varieties had been grown in previous years. The alkali reclamation work occupied much of the time of the Station force. The following table shows the yield of drilled wheats, on land that was partly alkali. All were sown December 9th and 10th, 1892.

Wheat—Season of 1893.

Name.	Length of Drills.	Number of Drills.	Yield.
Archer's Prolific	100 feet	4	25 lbs.
California Spring	100 feet	6	44 lbs.
Clawson	100 feet	2	14 lbs.
Defiance	100 feet	3	16 lbs.
Greek Atlanti	30 feet	5	8 lbs.
Indian Three-months	100 feet	4	32 lbs.
Michigan Mixed	100 feet	2	17 lbs.
Missoyen	30 feet	4	7 lbs.
Palestine	30 feet	3	6 lbs.
Rust-proof, Indian	100 feet	3	16 lbs.
Volo	20 feet	3	5 lbs.
Whittington	100 feet	4	24 lbs.
Yellow Noe	100 feet	3	18 lbs.

Himalaya Barley.—On December 11th, 1½ pounds of Himalaya barley, Experiment Station selected seed, was sown broadcast upon 7,600 square feet of the average soil of the Station tract. It received no extra care, nor any irrigation, and the total rainfall of the season was only 7.44

inches, but the crop yield was 250 pounds of clear seed. Deep plowing and thin seeding were the secrets of this result. This is a very early barley and a very heavy yielder. It would be profitable for hog-raisers in the San Joaquin Valley; probably a better barley for this purpose than any of the lighter-colored varieties.

Nepaul Barley.—The best barley so far tested for hay is Nepaul, a beautiful beardless barley that seems to suit the district in every particular. The head is large and heavy, the straw is very soft and sweet, so that horses will eat the entire stem. There is much less waste than with ordinary barleys, or with wheat hays, which waste nearly all the straw. The Station bought no hay in 1893, and has surplus hay enough to carry us over 1894, should the hay crop prove a failure. The success of the Nepaul barley at the Station has been so marked that there has been an increasing demand for the seed, and several persons who obtained a small stock from the University of California are now growing and selling seed barley at 3 cents a pound. Two and three tons to the acre has been a fair crop at the Station with ordinary field cultivation.

Sorghum.—This crop has been made a specialty at the San Joaquin Valley Station, chiefly through the persistent efforts of the foreman, Mr. Julius Forrer, who has distributed a great deal of seed of the best sorts in our collection, so fully described in earlier reports. *Sorghum vulgare* proves to be an improvement on the ordinary Egyptian corn, ripening three weeks earlier and yielding more to the acre. Sometimes there are twenty or more heads to one plant. This sorghum is also of a more dwarfed growth than the Egyptian, and appears to thrive on drier soil. Horses and cattle will eat the stalks quite as well as they do the common sorghums.

FIGS AT TULARE STATION.

By Julius Forrer, Foreman.

The fig trees at the Station have done very well in many cases, and the collection continues to attract notice from all summer visitors. While the general observations made in previous seasons continue to hold good, there are many details respecting varieties that require additional notes.

Abondance Précoce.—Only a medium grower, but with short, stocky branches, and quite hardy. The small fruit is abundant. The figs are light-brown, streaked with green, and the rich flesh ranges in color from white to dark pink.

Agen.—A slow-growing variety, one of the hardiest in the list. Fruit small, but excellent. It is a fair bearer, though not as good as some.

Angelique.—Slow grower here, and touched by frosts; has not yet fruited.

Bourjassottes (Black, Green, White, and Gray).—All four varieties, though thrifty, are somewhat tender. The white does not mature its fruit, though the tree is of good size, and should bear. The black is still small. The gray suffers from frost. The green is the hardiest of the four, and bears well; its fruit, medium in size, grayish in color, and red-fleshed, is of excellent quality for its type.

Breba.—A vigorous grower, and hardy. An immense number of figs are set and some fall off. No fruit has ever matured.

Brown Turkey.—A slow grower, and hardy. The light brown fruit has pink flesh and is medium in size; the tree is a moderate bearer.

Brunswick.—A good grower, but more tender than the majority of figs. The fruit has a peculiar shade of brownish-yellow and its flesh is pink-colored and sweet. The fig much resembles the Smyrna of California, and the growth of the trees is similar, but the leaves differ in shape.

Cernica.—This variety stands the frost well, but is not yet bearing.

Col di Signora Bianca.—This strong-growing variety is as hardy as any except Dorée Narbus, and it bears very heavily. The fruit is medium sized and of good quality.

Dalmatian.—This fig is a slow grower, and quite hardy. The fruit in color, size, and quality greatly resembles the Smyrna of California, and the Brunswick, except that it is more flattened and one-sided in shape. The ordinary grower does not need more than one of the three varieties.

Dattato (Black and White).—The black is a very small tree, but appears quite hardy. The white is more susceptible to frost.

De Constantine.—This vigorous grower stands the frost well, and bears heavily. The medium-sized, purple fruit is striped with green toward the stem, and its dark-red flesh is of fine texture.

Dorée Narbus.—This is a very strong grower, with short-jointed, sturdy branches of peculiar appearance. It easily withstands frost at 20°, and has withstood 17°. The small fruits, of very light yellow hue, are delicious in flavor. The white flesh, cream-colored at the core, is very juicy and sweet. Its bearing qualities are excellent, and this tree can be recommended for the home orchard in cold, frosty, or windy situations.

Drap d'Or.—A firm grower, but the tree is quite tender, suffering materially at 20°. The fruit is choice in quality, flesh white with pink center, and the skin of a light brown color.

Du Roi.—A very attractive and valuable acquisition. A hardy, good grower, and heavy bearer, covering an extended season. The medium-sized figs are white in color, and the flesh is white, deepening to a cream-tinted core. In quality, the fig is unsurpassed, and many think unequaled by any of the other varieties grown here. Du Roi and Hirtu Du Japon maintain themselves as two of the best table figs, and each successive season has only confirmed their value. In hardiness, Du Roi affords a refreshing contrast to the White Adriatic.

Early Violet.—The tree has suffered severely from frost and is not yet bearing. Like several other varieties, it is too tender for the locality.

Gros Gris Bifère.—This has proved a most tender tree, even light frosts affecting it. It starts up in spring and makes rapid growth. On poorer soil it might prove hardier, but it is evidently more suitable for the frostless districts. No fruit as yet.

Grossale.—This and the *California Black* are both small trees not yet in bearing, but have stood the frosts well.

Hirtu Du Japon.—This notable variety, new in California, deserves high praise and general introduction. It is of slow, compact, hardy growth. Indeed, it might almost be called a dwarf fig, making little wood. Its immense load of fruit is astonishing, and it is nearer to a perpetual bearer than any other fig at the Station. The round, purple figs are of medium size. The flesh is white, but with brown specks of imperfect seeds, and cream-tinted heart. The quality is unsurpassed

among all the figs. This is one of the best varieties for the garden, yielding twice as much to a given surface as any of the older varieties, and better for the table than any except the Du Roi.

Ischias (White, Brown, and Black).—The White Ischia, a very old and famous variety, is a slow grower here, and stands frost well. The fine-textured, delicate fruit ranges in size from small to medium, and is one of the sweetest and best on the list. Brown Ischia, in growth and hardiness, resembles the white, and is a heavy bearer. The black is more tender, bears well, and yields an excellent and very sweet fig.

Ladora.—Here is another variety of doubtful hardiness here, though it will fruit. The figs are slender in shape, brown in color, and of very fair quality; size medium.

Marseilles (Black and White).—The Black Marseilles tree is thrifty, but quite tender. The small, jet-black fruits are very sweet, and of high quality here. The stems are twice as long as the fruits themselves. A better family fig in the foothill districts than the more common White Marseilles, as it seems to be a better bearer, and preferable as an eating fig, though the white is of larger size here. There is little difference in growth of the trees, or in hardiness.

Monaca Bianca.—This proves to be a thrifty grower here; tree as tender as the Drap d'Or. A small, yellowish fruit, white fleshed, with pink center. The quality is fair to good, and the bearing capacity is large.

Negro Largo.—One of the strong growers, but decidedly susceptible to frosts of 20° and 21°. The fruit ranges from large to very large—a long black fig, sweet, and not coarse in grain. It is an excellent bearer here, and a very showy variety for exhibition purposes.

Osborn's Prolific is certainly well named, as it proves one of the best bearers. In growth of tree and hardiness it resembles the White Ischia. The small, rich, and sweet figs, brown in color, are of high quality.

Pasteliere.—A particularly thrifty grower, with short, strong joints. It is a hardy, early bearer, and productive; the fruit is large, long in shape, and with red flesh; the quality is from fair to very good.

Petrovaca.—A most vigorous grower, and very hardy, but, like Breba and the Bulletin Smyrna, the fruit does not stay on the tree.

Rargigna.—This is a strong-growing, hardy, moderate bearer. The medium-sized fruit of light cream, almost white color, has a perfectly white flesh. This is the most juicy of all the varieties grown at the Station.

Rocardi.—This is here a good grower, fully as tender as Drap d'Or. The fruit is small, greenish in color, with delicate purple stripes over the larger end; the flesh red and rather coarse. Quality is distinctly second-rate here; an excellent bearer.

Ronde Noire.—A strong grower, sensitive to frosts, but still bears in ordinary seasons. The skin is purple, the flesh dark-red to the core, and of very rich flavor. It is of the best of the dark-fleshed type, to which the Black California belongs.

Ronde Violette Hâtive.—Is here a very vigorous grower, and easily withstands 20° Fahr. The fruit ripens in July, is one of our earliest varieties, and in size ranks as medium to large. The color at the stem end is green, shading to brown at the apex. The first crop is also the main one; hardly any second crop. The fig is very solid, and yet juicy. It is one of the best for preserves and sweet pickles.

Royal Vineyard.—This fig, though a slow grower, is much subject to frost. The brownish fruits of medium size are of fair though not high quality.

San Pedro.—This is well recommended as a table fig elsewhere, but, like Gros Gris Bifère, freezes down every year at the Station.

Smyrna (true; Bulletin).—The tree is a vigorous grower and more hardy than any other large fig. Like the Breba, an immense number of figs have set, but all have fallen off when small. Caprification with pollen sent from a bearing tree of Capri, or wild fig, in the orchard of James Shinn, Niles, was attempted. The season was late here, before the pollen was ripe at Niles, and hence it did not take very well, but several figs that were pollinated matured. They were rather large, round in shape, juicy and delicious. The flesh was perfectly white and of unusually fine texture. A remarkable fig in all respects, and worth every effort to bring into full bearing.

Smyrna (of California).—A slow grower here, perhaps partly due to location; stands frost well. The fruit is greenish in color, tinted to brown; the flesh white, with pink center. It is not a heavy bearer.

Trojano.—A small tree, and was frosted last winter.

White Adriatic.—Probably the best known fig now in cultivation in California, and very useful for purposes of comparison. Ordinarily, and particularly on the heavy, alkaline soils here, the growth of this variety is very sturdy and rapid. But the tree suffers as much from frost as any other variety known; it seems sometimes as if it suffered even more than others, and loses large branches. Notwithstanding the great reputation the fruit bears, it seems to me evident that here, at least, it is one of the poorest that we grow. The coarse-textured red flesh is not attractive, compared with other varieties, and the thick, tough skin often bursts at the apex, so that the flesh sours in this climate. The juice is often seen running out on the ground, and swarms of wasps and bees haunt the trees. No one in Tulare will plant White Adriatic any longer.

White Brogiotto.—A good grower and of medium hardiness, but the tree has not yet borne fruit.

White Genoese.—Strong grower, but very tender; no fruit.

BUILDING AT SOUTHERN CALIFORNIA EXPERIMENT STATION, NEAR POMONA.

E. SOUTHERN CALIFORNIA STATION.

In the Chino Valley, between Pomona and Chino.

By CHARLES H. SHINN.

The Southern California Experiment Station is becoming more and more attractive to the visitor. It lies in the heart of the great Chino Valley, close to the boundary line between San Bernardino and Los Angeles Counties. Chino, Ontario, and Pomona are already closely connected by steam railroads, and several electric lines are projected in the valley. Farmers from every part of Southern California can easily reach the Station grounds at any time of the year, and are always welcome there.

General View.—The Station was established in the autumn of 1890, and the planting of vines and trees began in the spring of 1891. Additions were made to the orchard and vineyard in 1892 and 1893. The 30-acre tract consists of a parallelogram of 22 acres extending east and west, with 8 acres attached in a smaller square on the south. This gives a better variety of soil than if the whole tract had been made square. The buildings are near the southeast corner, and are well arranged, with ample walks and driveways, which are now being covered with asphaltum given to the Station by Mr. Richard Gird, from his large asphaltum mine in the hills near Chino. A street lies on the east side of the tract, and another street on the north, both open and being built upon.

Nearly all the large parallelogram above referred to is devoted to orchard and vineyard, planted and in good condition. The chief exception is in the arboretum and nursery blocks, which occupy a comparatively narrow strip extending west from the house, along the northern line of the tract. The arboretum is a block 210 feet wide and about 400 feet long, including the circular reservoir of 60 feet in diameter. This is being planted to specimen trees grouped so as to leave vistas across the reservoir and will not only add to the beauty of the place, but must also serve as additional shelter to more tender plants in the garden. West of the arboretum, the small fruits, nursery, vegetable garden, grain plots, and small cultures extend to the northwest corner of the tract.

The small square south of the larger parallelogram, heretofore used for hay growing, will be needed for orchard before long, and the olives, cherries, plums, and apples are already extending south over this part of the Station tract. In the main orchard, thirty-eight rows of trees are planted, and all of them except a few on the Station side where the stable and roadway occupy some space in the edge of the orchard, consist of twenty-six trees. When extended across the hay field, there will be room in all the sub-orchards for nearly 1,500 trees, and the planting has been so wide apart that small fruits can be grown between many of the rows. Restricted to two trees of leading varieties and one tree of

varieties of less importance, a thousand varieties can easily be represented here.

The earlier difficulties of establishing the Station have been met and overcome. A change of foremanship made in the autumn of 1893 was the most important step taken since the last report. The new foreman, Mr. J. W. Mills, has been both active and efficient in his work, and the Station has greatly improved under his management. Public interest in the work of the Station is greater than ever, and we are indebted to many citizens of Pomona, Chino, Ontario, Riverside, Redlands, and Los Angeles for visits, and in many cases for rare seeds and plants. There is no place in California where earnest and capable horticultural work is more readily appreciated than in this district. Intensive horticulture is everywhere developing along broader lines; olive, orange, and lemon groves extend in a broad belt along the base of the mountains, while the culture of sugar-beet and deciduous fruits occupies the heart of the valley. The more notable home colonies of Southern California are within reach. In no other region where an outlying Station has been established is there better material, or more interest in the work to be done. From its foundation every newspaper in the three towns of the valley, and many outside, has devoted more than ordinary attention to the Station.

Improvements.—During 1892–93 an addition to the barn was made, doubling the size of floor space and affording room for wagon and tool shed, additional hay, etc., and much improving the general appearance of the place. More water pipe was laid, hot-bed frames built, and repairs made as needed in the house. The water supply from the reservoir for orchard and nursery irrigation proved sufficient, but it will be necessary to build a tank-house and use a small windmill to furnish the house supply. The pressure obtained from the main pipe is barely sufficient to fill the 100,000-gallon reservoir used for irrigation. A hose cannot be used in the garden without greater pressure, only to be obtained by a tank and a windmill. A system of distributing water is now being arranged by which the exact amount used can be determined.

THE ORCHARD.

Every visitor is pleased with the fine growth of the fruit trees. Since the last report, many additions have been made. There are but few seedlings and comparatively few changes to be made in the sub-orchards.

Sparrows and other small birds last winter ate many buds of peach, almond, apricot, cherry, and nectarine. Mr. Mills shot and poisoned some, and sprayed his trees with various compounds that it was thought might stop their depredations, but a large part of the fruit crop was lost. The orchard lies on the outskirts of the settlement and suffers more than others in this region, but there is a difference in the seasons, and in some years birds do little or no damage. Last year they were especially troublesome in many districts.

Olives.—Olive-culture is rapidly becoming one of the most important industries of the Chino Valley. The headquarters of the business is in and near the town of Pomona, and some of the most intelligent olive-growers of California belong in this district. With great liberality these gentlemen have sent to the Station trees of every new variety of

olive obtained by them, and our collection promises to become one of the best in the United States, if not, indeed, already the largest of its kind. It includes sixty-six distinct varieties, and there are two or three good specimens of each variety. Besides this, we have about one hundred seedlings of Rubra that have not yet fruited. The complete list of varieties is given in the appendix to this report, tabulated as a supplementary list of the fruit trees at the various stations.

The olive sub-orchard begins along the southeast side of the tract, and occupies seven rows. There are a few vacancies to be filled, and the orchard can be extended south, into the block that is now used for growing hay, so that there is room for many more varieties. The seedlings are chiefly planted in the main streets. Many of the trees are three years old, and the best grower in this class has been Nigerina. Huff's Spanish, Nevadillo Blanco, Præcox, and Pendulina are also excellent growers.

Lemons.—The lemon sub-orchard is really only a part of the citrus-fruit orchard, of five long rows, immediately west of the olive orchard. The representation of varieties is small as yet, though some promising new sorts have been obtained from prominent lemon-growers of Ontario, a notable lemon district. Stock had also been planted to use for top-working new varieties of oranges and lemons in the budding season. Lisbon, Eureka, and Villafranca are the largest three-year-old trees in the orchard.

Oranges.—The California and the older Florida varieties are fairly well represented in the Station. New sorts are now being obtained. A large number of choice seedling stocks have been set in orchard form ready to top-work, so as to hasten the bearing of any new variety. Space has been reserved so that the citrus fruits can be given a larger representation every year. Two trees of each variety have been planted, except of Washington Navels, of which twelve were set to facilitate future experiments, and six of them will be reserved. All the orange trees have grown well; the Pineapples and Magnum Bonums are as large as any.

Almonds.—West of the citrus fruits is the one almond row, which affords room, however, when extended across the tract, for all the desirable varieties known to horticulturists. Almonds have been a genuine surprise to the district, so well do they grow, and such bearers did the three-year-old trees prove, last season. The blossoms have not yet suffered from frost, and if the birds leave the buds alone, an almond crop seems safe in this region. Even the Languedoc bore well in 1893–94. The strongest-growing tree is Drake's Seedling, with Golden State and Marie Dupreys a good second, and Nonpareil and Sultana about equal. The almonds attracted much attention, and were visited by many orchardists, some of whom decided to plant commercial almond orchards upon the strength of the showing made. Very little almond planting had been done before in the Chino Valley.

Cherries.—Still farther west comes the cherry row. In this district the cherry is probably destined to be a fruit of secondary value, though some of the southern Russia sorts may stand the heat better than the common European types. The trees grow but poorly and "gum" badly. They were, of course, headed as low as possible, and have been well cared for. Elton, Rockport Bigarreau, and Willamette are probably the

best trees in the row. The soil is light for cherries, and much better places for the fruit can be found in the region.

Peaches and Nectarines.—Five rows follow west of the cherry row, and these are devoted to peaches and nectarines, which most resemble each other in general character of growth. There is a good collection of both fruits, embracing some of the standard varieties and many of more recent introduction. The trees have grown evenly, and twenty or thirty might be named as of equal merit in point of size and shape. This sub-orchard will be enlarged considerably, as the district is well adapted to peaches and nectarines. The finest nectarines in the sub-orchard are Pitmaston's Orange and River's Orange.

Apricots.—West of the peach orchard are the apricots, occupying most of rows 19 and 20. The finest tree in the tract is the Blenheim. As a rule the growth of the trees is very satisfactory. It will be advisable to remove a few plums from row 20, so as to devote that row entirely to new apricots, of which many sorts are being propagated at the Central Station.

Plums and Prunes.—Six rows and part of another are occupied by this sub-orchard. It is in excellent shape and makes a very good collection. Most of the trees have been two and three years planted, though there are a few yearlings. Two seedlings and the Marianne plums are the largest in the orchard, but the average, as represented by Bulgarian prune, have made satisfactory growth. As with the other sub-orchards, some extension is practicable whenever necessary.

Pears.—In point of completeness, the pear collection, occupying five rows, leaves little to be desired, but the light soil of the main station tract is not well suited to this tree, and they have made the poorest growth of any trees in the entire orchard. From the present prospects, it will be wise to graft over duplicates and keep but one tree of a variety in this sub-orchard. We will be able to test one hundred and twenty varieties in this way without extending the orchard; meanwhile, we can start a pear orchard on the heavier soil of the ten-acre tract, which is much better adapted to this tree. There is no doubt of fair success with the pear on the main tract, but the fruit will be probably of only medium size, and the growth of the trees will be slow.

Apples.—The apple has been comparatively neglected in the Station, few varieties having been planted up to the present time. Row 35, in the main orchard east of the pears, is devoted to "apples and crab-apples," and a number of trees have been set in the hay field south of the orchard. The more recent plantings are mostly Russian varieties. The representation of varieties will be very materially increased in a few years, as something like a hundred new and rare sorts of apples are being propagated at the Central Station. We are selecting the finer seedlings from the Southern States, the Crimean provinces, and southern France, aiming to give this district choicer table and market apples. While the trees are of rather slow growth, they seem to thrive better than the pears, and the apple sub-orchard justifies further extension.

Figs.—The last three rows of the main orchard are devoted to figs, a fine collection, now almost complete, capable of receiving twenty-five new varieties, but already, as with the olives, a very choice and extensive plantation. Agen seems to be the best grower. Many of the trees are so young that as yet they offer few noteworthy characteristics. The trees suffer little from frost here, and it is evidently a good fig

district. With the number of varieties here planted some valuable observations can be made as soon as they come into bearing, respecting the cause of "souring" on the trees, which evil has often ruined large crops of certain varieties in Southern California.

Grapes.—West of the fig sub-orchard is the main vineyard, where a large number of wine and table grapes are planted on very suitable soil, and have made very fine growth without irrigation. Some varieties bore a small crop in the season of 1893, and the coming season will probably enable us to make shipments to the Central Station to correct the nomenclature wherever faulty, and graft over the surplus stock. As with the olive, citrus fruits, almond, peach, apricot, and fig, the district is well suited to many grapes. More complete details will be found from time to time in special viticultural reports.

Walnuts and Chestnuts.—A very complete collection of grafted and seedling walnuts and some fine varieties of chestnut and of filbert were planted at the Station. It is perhaps too soon to say much about them, except that they seem to need considerable water until established. Walnuts have done well in the district and will doubtless thrive here.

Fruit in 1893.—The orchard was so young that no fruit at all was expected last season. Nevertheless the almonds yielded as follows: Sultana, three quarts; Ne Plus Ultra, Paper-shell, I X L, Flat-fruited, one quart each. There was one tree of each of the above kinds that bore fruit. The oranges that bore were of the Ruby, Homosassa, Tangerine, and Pineapple varieties, and the trees yielded from four to twelve fruits apiece.

CEREALS AND SMALL CULTURES.

Sorghum.—Fair growth, without irrigation; crop not used for fodder. Only small lots were planted in sandy soil, west of the vineyard. Whiting, New Orange, and Early Amber were among the best.

Perennial Cotton.—The plants survive, though killed back nearly to the roots by the light frosts. It is evidently a very tender plant from the *tierra caliente* region, and unlikely to succeed in any part of California. The chief trouble is in the late blooming. If the plants could be forced into earlier bloom they might possibly ripen up sufficiently to stand the winter better. In 1892 they bloomed in December; in 1894, in November.

This plant is known in its native region as the Catacaos cotton, and grows in great perfection along the banks of the Pima River in Peru. It reaches a height of 12 feet, and under favorable circumstances yields 350 pounds of clean cotton per acre, in two crops, January and August. This cotton is worth from three to seven cents a pound more than ordinary cottons. Its best soil is said to be deep and naturally moist loam. Eight years is the usual period of a plant's productive life. It is unlikely that more than one crop annually could be obtained in California, unless along the Colorado River.

Sugar Cane.—A poor start was made in 1892, when four out of five varieties sent from Louisiana failed to grow. The one remaining variety, the striped, did not receive enough water and only gave us a little stock for future planting.

Cereals.—A large collection of grains was grown in small test plots in 1893, but too late for the season or the district, and receiving little culti-

vation, made such poor growth that orders were given to cut all but the ten or twelve best plots, for hay. The former foreman failed to keep any record of the cereals or of the grasses and clovers, so the report is necessarily defective. With early sowing and thorough cultivation, a fine collection of cereals could have been obtained for exhibition purposes, as well as for the comparative tests to ascertain the best varieties for the region, but this must now be left for another season.

THE MOIST-LAND TRACT.

In the autumn of 1892, arrangements were made to break the sod on the moist-land ten acres, two miles west from the main Station grounds. Some work had been done here at intervals, but nothing of any consequence. A contract was let to have the whole ten acres plowed twice, and harrowed twice, using a six-horse team. Grass seed, sorghum, and corn were planted on four acres, and corn, squashes, and beets on the remainder. The soil proved very weedy, crop after crop of sunflowers springing up, and the ground remaining wet late in the spring and running together into a fine sod of grass and lowland growth. Wire-worms in the sod destroyed the grass seed and alfalfa sown, but the corn, squashes, etc., made a fine crop. There was not nearly enough cultivation of this tract through the summer of 1893, and the new foreman, Mr. Mills, has had to do the work over again, in a large measure, but is now master of the situation.

Value of this Land.—No other Station has so useful and attractive an adjunct as this ten-acre tract. Without drainage it is unfit for many species of trees, but in the course of time a general system will be adopted for the lowlands of the valley, and this tract will become of especial importance. Even in its present condition, it ought from this time forward to furnish all the hay and fodder that the Station requires, besides growing complete tests of many grasses, clovers, and forage plants, beets, melons, squashes, and a large range of moist-land crops. Some tree-planting on this tract is planned for next winter. In the end, at least half of it can be devoted to trees and vines. It is not necessary to fence it, as cattle are now shut out from this portion of the Chino ranch on account of the sugar-beet crops.

Grass-Sowings, 1893, 1894.—The following grasses were sown by Mr. Mills in the present season, 1893–94: Hungarian Brome Grass (*Panicum Germanicum*), Mesquite, or Velvet Grass (*Holcus lanatus*), Red-Top (*Agrostis vulgaris*), Perennial Rye Grass (*Lolium perenne*), Timothy (*Phleum pratense*), Tall Oat Grass (*Avena elatior*).

SWEET POTATOES.

Literature of the Subject.—Several experiment stations have made studies of the sweet potato. The Maryland station issued, in October, 1892, a bulletin on the subject prepared by E. H. Brinkley, Assistant Agriculturist. The census shows that North Carolina leads all the States in the sweet potato crop (4,500,000 bushels average annual yield). Georgia, Mississippi, and Alabama follow in the order named. New Jersey stands highest in the average yield per acre. Maryland stands eighteenth in total acreage, thirteenth in yield, and ninth in average yield per acre. The test made by the Maryland station was

simply with reference to fertilizers, and the largest crop per acre was obtained on sandy loam fertilized with sulphate of potash at the rate of 200 pounds to the acre. The non-fertilized check-plot yielded at the rate of 3,200 pounds.

A more complete paper on sweet potato was issued in December, 1893, by Professor R. H. Price, of the Texas Experiment Station. He states that the total value of the sweet potato crop of Texas is over $1,500,000, and that while the value per acre of cotton is but $15 36, the acre value of sweet potatoes is $50 24. He states that the tops are an important feed for stock, especially for dairy cattle. Thirty-one varieties were tested. He thinks the Vineless one of the best.

Another excellent report upon sweet potatoes came from the Louisiana Experiment Station, and was written by Professors B. B. Ross and H. A. Morgan. This is a very important bulletin, full of details, and includes a careful compilation of historical data respecting the origin and distribution of *Convolvulus batatas*, the true sweet potato. The Louisiana Experiment Station at Baton Rouge undertook to gather an extensive collection of varieties of sweet potatoes, test them thoroughly, and determine the nomenclature, long in a state of utter confusion. It was at this station, in fact, that the renewed interest in this crop began, about 1891.

The Louisiana station tested fourteen varieties at this time. The largest yield per acre was given by the Pumpkin Yam, 331 bushels; Red Nansemond came next with 302 bushels; the third largest was from the Californian, or Shanghai, 276 bushels. Some much more popular varieties for table use, such as the Sugar Yam, Southern Queen, and Norton, yielded at the rate of from 97 to 170 bushels. Some fertilizer experiments showed that on loose, sandy loam (the best soil for sweet potatoes) phosphoric acid was highly profitable, but an excess of nitrogenous fertilizers makes too much growth of vines.

In classification of varieties respecting shape, size, and quality, the system adopted in the Louisiana report leaves nothing to be desired. It must be premised that Northern people usually prefer the dry, starchy varieties, but Southerners favor the sweet and syrupy varieties. There are four distinct types of sweet potatoes: (1) Those that are roundish, and mealy when cooked, as Southern Queen, Red Nansemond; (2) those that are long and slender, and also mealy, as New Jersey Vineless and Spanish; (3) those that are roundish, soft, and very sweet when cooked, as Sugar Yam; (4) those that are long, slender, soft, and sugary, as Georgia Yam.

Trials at the Southern California Station.—A collection of the leading varieties of sweet potatoes was sent to the Station by the Director of the Louisiana Experiment Station in the spring of 1893. The roots were planted in a hot-bed and the sprouts taken off in the usual manner and set in sandy soil, west of the orchard. They undoubtedly received too much irrigation during the summer, as even the varieties naturally mealy were less so than usual. All were unfertilized.

The following notes upon twenty varieties tested are by Mr. J. W. Mills, the foreman of the Station. Samples of each were sent to Berkeley and analyzed by M. E. Jaffa, whose report will be found in the chapter on fruit and vegetable products, on page 220.

Barbadoes.

Tubers, 7 to 10; regular in shape, uneven in size, small to medium; flesh and skin pale yellow.
Vine, 4 to 6 feet; slender, fibrous; juice colorless; internodes, 1 to 1¾ inches long.
Leaves, 2 to 3½ inches wide; five parted (almost divided), dark green; mid-ribs and cross-veins hirsute beneath, hispid above; two to three at each node.
Petioles, 2 to 2½ inches long.
Product of two best hills weighed 7½ pounds.

Bermuda.

Tubers (only one vine), 14; skin bright reddish-purple; flesh white, brittle; tubers long and crooked (one 2 feet long). Tubers penetrate deeply; roots small.
Vine, 5 to 8 feet long, dark purple, scarcely fibrous; internodes, 2 to 2¼ inches long, smooth; juice slightly milky.
Leaves very dark green, 4 to 5 inches wide; three-lobed, middle lobe long; five-pointed, smooth above and below.
Petioles lurid purple, 4 to 6 inches long.
Product of the hill was 17½ pounds.

Big-Stem Jersey.

Tubers, 6 to 12; average large, regular in size, yellowish white, sprouts easily. Stem rather large.
Vine, 5 to 7 feet long, thick stem, fibrous, slightly purple; milky juice.
Leaves, 3 to 4½ inches broad, almost entire, hirsute.
Petioles, 5 to 8 inches long.
The two best hills yielded 24 pounds.

California (Shanghai).

Tubers, 5 to 8, small to medium, light-colored skin, flesh white; ring of cells ¼ inch beneath skin; exudes milky juice.
Vine, 1½ to 3½ feet long, fibrous, with milky juice in bark; hirsute; internodes, ¾ to 1 inch long.
Leaves, 3 to 4 inches broad, entire, three-pointed; mid-rib faint reddish-purple about one inch from petiole, deepening to intense color down nearly to the petiole.
Petioles, 6 to 8 inches long.
The two best hills yielded 7½ pounds.

Dog River.

Tubers, 5 to 9; flesh and skin carrot-yellow; long, slender, smooth, and above medium size.
Vine, 4 to 6 feet long; thick, glabrous; numerous runners; internodes, 1½ to 2 inches long, fibrous; juice clear.
Leaves, 2 to 2½ inches wide; entire, smooth beneath, hirsute above.
Petioles, 5 to 7 inches long.
The two best hills yielded 9¾ pounds.

Early Golden.

Tubers, 4 to 12; large to small, few being medium sized; breadth greater than length in large ones; large ones with pink blotches.
Vine, 3 to 4 feet long; one fourth of an inch in diameter, very fibrous; juicy, slightly milky.
Leaves, 4½ to 5½ inches broad; almost entire, smooth below, slightly hirsute above.
Petioles, 5 to 9 inches long.
The two best hills yielded 17¾ pounds.

Golden Skin.

Tubers, 5 to 8; small to medium; yellow skin, almost white flesh.
Vine, 3 to 6 feet long; slender, fibrous; internodes, 2 to 4 inches long.
Leaves, about 2 inches broad; entire, three-pointed; smooth beneath, shortly hispid above.
Petioles, 2 to 4 inches long.
The two best hills yielded 5¾ pounds.

Hayman.

Tubers, 4 to 9; small to medium; yellowish white.
Vine, 3 to 3½ feet long, ¼ of an inch in diameter; fibrous, slightly hirsute; milky juice.
Leaves, 4 to 5½ inches broad; entire, with 3 to 4 points, almost smooth above and below.
Petioles, 5 to 9 inches long.
The two best hills yielded 7½ pounds.

Matejito.

Tubers, 4 to 5; medium size; flesh bright yellowish red, skin light.
Vine, 4 to 7 feet long; very slender, fibrous; thin, milky juice.
Leaves, 1¼ to 2 inches broad; hirsute below, hispid above; cauline leaves almost entire, others three-lobed.
Petioles, 2 to 3 inches long.
The best two hills yielded 9½ pounds.

Nameless (label lost).

Tubers, 2 to 4; very large, inclined to crack; skin bright pink, flesh light yellow; rather irregular in shape, inclined to be round.
Vines, 4 to 7 feet long; medium size in diameter, very fibrous; inclined to lurid purple through whole length; juice very thick and milky.
Leaves, 2 to 4 inches wide; nearly entire and three-pointed; mid-ribs and cross-veins purplish beneath, leaves sub-glabrous above and below.
Petioles, 3 to 4 inches long; purple at each end for about three fourths of an inch.
Two best hills weighed 29¾ pounds.

Red Nansemond.

Tubers, 4 to 6; very large; irregular and diversified in shape; yellowish white.
Vine, 4 to 6 feet long; slender for length; medium amount of milky juice; vines slightly purplish; internodes 2 inches long.
Leaves, 2½ to 4 inches broad; purple at union of mid-ribs and petioles; entire to three-parted; smooth beneath and minutely hirsute above.
Petioles, 4 to 5 inches long.
The two best hills weighed 18½ pounds.

Yellow Nansemond.

Tubers, 6 to 16; small and regular; skin yellow, flesh light yellow.
Vine, 2 to 2¼ feet long; slender, fibrous; juice slightly milky; internodes, 1½ to 2 inches long.
Leaves, 2 to 2¼ inches wide; entire; sub-glabrous beneath, hispid above.
Petioles, 2 to 3 inches long.
The two best hills weighed 7¼ pounds.

New Jersey.

Tubers, 6 to 8; medium size, regular, elliptical and pointed in shape; yellow skin; pale yellow flesh; perfect in shape and color, but sprout easily.
Vine, 4 to 6 feet; slender, fibrous, rough; internodes, 2 to 2½ inches long; juice milky.
Leaves, 1¾ to 2 inches wide; entire; smooth beneath, hirsute above.
Petioles, 2 to 4 inches long.
The two best hills weighed 7¼ pounds.

Norton.

Tubers, 2 to 6; large and irregular; skin pink; flesh light yellow.
Vine, 4 to 7 feet long; purple; slender for the length, and very fibrous; abundance of milky juice.
Leaves, about 4 inches broad; lower surface almost smooth, upper surface hispid.
Petioles, 5 to 8 inches long.
The two best hills weighed 19 pounds; one tuber weighed 8½ pounds.

Peabody.

Tubers, 7 to 9; large, round, smooth, fairly regular in size; skin white, flesh pale yellow.
Vine, 4 to 6 feet in length; thick in diameter, medium fibrous; milky juice; generally purple 2 or 3 feet next to root; internodes, 1½ to 2 inches long.
Leaves, 4 to 6 inches broad; smooth above and below; mesophyll rather thick.
Petioles, 4 to 7 inches long.
The two best hills weighed 19½ pounds.

Providence.

Tubers, 2 to 5; large and irregular; skin white, flesh yellowish.
Vine, purple for about 3 feet from root, 4 to 6 feet long; fibrous; juice thick and milky; vine hirsute; internodes, 1½ to 2 inches long.
Leaves, 2 to 3½ inches wide; almost entire, three acuminate points; slightly hirsute above and below; veins purplish.
Petioles, 4 to 6 inches long.
The two best hills weighed 21 pounds; one tuber weighed 8¾ pounds.

Pumpkin Yam.

Tubers, 4 to 8; large; yellowish white.
Vine, 4 to 6 feet long; thick in diameter, very fibrous; dry milky juice; purple near roots; internodes, 1 to 1½ inches long.
Leaves, 3 to 5½ inches broad; smooth beneath, hirsute above; nearly entire; three-pointed.
Petioles, 4 to 9 inches long.
The two best hills weighed 25¼ pounds.

Southern Queen.

Tubers, 7 to 15; regular and medium in size; skin bright yellow; flesh pale yellow.
Vine, 5 to 7 feet long; slender, fibrous; juice milky; internodes, 2½ to 5 inches long.
Leaves, 2½ to 3 inches broad; three-lobed; hirsute above and below.
Petioles, 4 to 7 inches long.
The two best hills weighed 14 pounds.

Sugar, or Creole.

Tubers, 6 to 12; small; skin light, tinged with pink; flesh light, specked with light brown.
Vine, slender, fibrous; internodes, 1 to 1½ inches long.
Leaves, 1½ to 2 inches broad; five-parted; nearly smooth beneath, hispid above.
Petioles, 1½ to 3 inches long.
The two best hills weighed 3½ pounds.

Tecotea.

Tubers, 1 to 10; long and slender to short and thick; fair to medium in size; skin white, with pink blotches.
Vine, 2½ to 3½ feet long; very numerous and branching, one fourth of an inch in diameter; fibrous, with abundance of milky juice; pubescent; internodes, 2 inches long.
Leaves, 5 inches broad; mostly five-cleft; under and lower part of mid-ribs purplish; lower surface smooth, upper surface nearly smooth. Leaf thin and soft.
The two best hills weighed 12 pounds.

Vineless.

Tubers, 6 to 8; small; skin light yellow; flesh a quarter of an inch below skin is pinkish yellow, interior flesh light yellow.
Vine, 1 to 2½ feet long; thick stem, brittle, granular; juice clear; internodes, ½ to ¾ of an inch long.
Leaves, 3 inches broad; three to five-parted; scattering, fine hairs on cross-veins beneath; smooth beneath, hispid above.
Petioles, 5 to 6 inches long.
The two best hills weighed 4 pounds.

Quality.—As noted, the vines received too much water, but many varieties proved to be of excellent quality. An expert housekeeper tested a number of sorts, and reported as follows: "The dry potatoes of the Nansemond type are the best for baking, according to the usual Californian ideas, but the soft and sugary yams make by far the best fried potatoes, and ought to be extensively cultivated here. They were a surprise to every one who tasted them." Some separate varieties tested by the housekeeper were reported upon: The Bermudas were "mealy, but lacking in flavor." Pumpkin Yams were "of excellent flavor, but slightly stringy and very soft." Matejitos were "watery, stringy, quite sweet, resembling, when baked, a field squash." Hayman was "very fine flavor, particularly when fried, but too soft when baked." Providence was "of good flavor, very fine in grain, almost without fiber; rather watery when baked; would probably be a very popular variety, especially among those accustomed to Southern cooking."

F. THE FORESTRY STATIONS.

WORK OF THE STATIONS AT SANTA MONICA AND CHICO.

By C. H. Shinn, Inspector of Stations.

Establishment of Stations.—March 3, 1885, the Legislature of California created the State Board of Forestry, which remained in existence until July 1, 1893. Its history is contained in four biennial reports and in various other publications. According to the State reports, an experiment station was formally established near Santa Monica, December 20, 1887. It was afterwards moved to the tract now in use, which had been deeded to the State for forestry purposes. About this time Gen. John Bidwell offered to give some land on Chico Creek, and twenty-nine acres was afterwards deeded to the State. These two tracts, both fertile and admirably situated, remained in charge of the Forestry Commission during the rest of its existence.

March 23, 1893, the State Legislature, repealing the Act creating the Board of Forestry, ordered that "all the real and personal property of the said Board," on or before the first day of July, 1893, should be "transferred to the Agricultural Department of the University of California." The sum of $4,000 was appropriated to maintain the two stations, one at Chico, the other at Santa Monica, for the two fiscal years ending July 1, 1895.

According to the financial statements of the Secretary of the Board of Forestry, as published in the biennial reports, the total expenditure of the Board upon the two stations was $33,493 40 in fifty-four and a half months, or about $7,400 a year. The third biennial forestry report states that in 1890 there were 15,427 forest trees planted at Chico Station, besides 30,000 small trees in nurseries. No detailed report of the Santa Monica Station was made at this time.

The Stations in June, 1893.—Both the forestry stations were visited in June, to discover their actual condition. Both alike showed weediness, neglect, little or no cultivation, and ravages of stray sheep, cattle, and horses in the young plantations. Only a small proportion of the trees were labeled, and there were no tree registers, nursery books, maps, or memoranda at either station, hence age and history of the specimen trees can only be approximately ascertained.

CHICO STATION.

Taking Charge.—July 1, 1893, the station at Chico was transferred to the University. The tract of twenty-nine acres contained about eight acres in trees and nursery, half of which was in fair condition. The trees were scattered over the tract in isolated groups, and many specimens had been gophered, or girdled by squirrels. Some of these small plantations were so closely set and so overgrown that they were

practically worthless, it being nearly impossible to make straight, well-grown trees of them.

About 4,000 trees in all were found in plantation form. Of these, 707 were eucalypts, 1,998 pines, 122 maples, 497 box elders; the remainder were chiefly mulberries, catalpas, paulonias, poplars, willows, black walnuts, and umbrella trees. There was one fine block of 76 Sequoia gigantea. After the necessary thinning, the station will have in all about 2,000 well-established trees in plantation form, fit to make excellent growth hereafter and to become typical specimens.

The nursery plot and adjacent territory were covered with Johnson grass. A small tool-shed was on the land. A harrow, cultivator, and a few hand-tools constituted the movable property.

Reorganization of Station.—Colonel C. C. Royce, the general manager of Rancho Chico, consented to act as Patron. Colonel Royce recommended Mr. M. L. Gipson as a suitable person to take the temporary foremanship of the station, and he began work July 2d mowing and burning weeds. Two men were employed at intervals during the autumn to grub out scrub oak, willows, and other wild growth on the tract.

Through the kindness of General Bidwell and Colonel Royce the University obtained the free use of a barn on Rancho Chico near the forestry station; a team of strong horses was rented at a reasonable figure, and hay and grain were purchased. Beginning at the west end, the tract has been deeply and thoroughly broken and all the small plantations have been thinned and well cultivated.

The nursery, owing to the Johnson grass, was wholly worthless for nursery purposes. The deciduous trees were therefore dug and the conifers balled; specimen trees of some sorts hitherto unrepresented were set in the plantation and properly labeled. The surplus was distributed to school districts and various public institutions.

Present Condition.—At the time of this report, the close of the calendar year 1893, the main work of the planting season 1893–94 still remains to be done. If two or three acres can be planted every season with choice trees well cared for and accurately labeled, the Chico arboretum will soon begin to assume shape.

The station tract is nearly level, sloping gently west. It is in the shape of a triangle with the apex pointing east and the base lying parallel to the axis of the Sacramento Valley. The Chico V-flume lies on the southern side; Chico Creek extends along the northern side. A few fine large white oaks remain, and should never be cut. The soil is a red wash from the foothills, mixed more or less with the sedimentary soil of Chico Creek banks. Some gravel patches give variety, and an old Indian mound near the center of the tract gives the usual black, rich, "greasy" soil of such localities. The land is excellently well adapted to forestry purposes, and an immense range of tree growth can be tested here, in time to come. At a conservative estimate the tract is worth $3,000, without improvements, which, as already noted, are unimportant.

Within the past year the main road leading from Chico to the hill country, through the station tract, has been thrown open to the public; the avenue, eighty feet wide from the edge of the town, can be planted by the University with named species of trees. This is especially desired by the townsfolk, particularly by the Normal School people,

who hope for the speedy development of an attractive arboretum, not only at the station but all the way to town along the V-flume. Although the tract is well fenced (this having been done by General Bidwell), the gates have often been left open by teamsters in time past, and much injury has been done. Since July no sheep, cattle, or horses have been allowed on the station grounds, and as soon as planting begins on the avenue they can be shut out of there also.

Two men and one team are now at work all the time preparing the soil, removing the traces of former neglect, and caring for the trees already established.

Condition of the Plantations.—The Chico plantation, as reported by the Forestry Board in 1890, consisted of the following trees in permanent form:

Name.	No. of Trees.	Name.	No. of Trees.
Eucalyptus viminalis	2,463	Acer dasycarpum	306
Eucalyptus rostata	420	Salix (osiers)	208
Eucalyptus obliqua	550	Juglans nigra	210
Pinus Austriaca	1,652	Juglans rupestris	201
Pinus pinaster	708	Poplars	160
Pinus strobus	984	Fraxinus quadrangulata	57
Pinus insignis	123	Betula alba (white birch)	55
Pinus pinea	73	Morus alba (white mulberry)	47
Pinus Torreyana	70	Melia azedarach (umbrella tree)	38
Cupressus sempervirens	1,558	Japan maples	24
Cupressus Lawsoniana	372	English hawthorn	9
Pseudotsuga Douglassi	470	Weeping elm	6
Thuya occidentalis	228	Araucaria Bidwelli	2
Sequoia sempervirens	174	Picea pungens	4
Sequoia gigantea	100	Tilia Americana	4
Abies concolor	151	Magnolias	4
Catalpa speciosa	1,188		
Negundo Californicum	974	Total	15,437
Acer rubrum	763		

July 1, 1893, when the University took charge, these extensive plantations had nearly disappeared. Instead of 3,433 eucalyptus, only 707 were found; in place of 3,769 pines, only 1,998; the remainder of the plantation consisted of 122 red maples, 75 Lawson cypress, 16 elms, 8 ashes, 76 Sequoia gigantea, 497 box elder, 312 catalpas, 10 Silver maples, 10 mulberries, and so on. In all, the entire station contained less than 4,000 trees in plantation form. After the necessary thinning out now required, as the trees were originally planted too close together, the Station will begin the year of 1894 with not more than 2,000 trees in plantation, but these will all be fine, healthy, and well established, fit to make a large growth in the next ten years, if continued thinnings give them space to develop.

The Present Plantation.—The present plantation, including the addition of the winter of 1893, now contains representatives of the following species:

Aberia kaffra.
Abies Menziesii.
Abies concolor.
Acacia decurrens.
Acacia melanoxylon.
Acacia longifolia.
Acacia cyanophyllum.
Acer rubrum.
Acer dasycarpum.
Araucaria Bidwelli.
Arbutus unedo.
Betula alba.
Buxus communis.
Buxus aurea variegata.
Carica papaya.
Catalpa speciosa.
Cedrus Deodara.
Celtis occidentalis.
Ceratonia siliqua.
Citrus trifoliata.
Cotoneaster microphylla.
Cornus Nutalli.
Cratægus oxyacantha.
Cupressus sempervirens.
Cupressus macrocarpa.
Cupressus macrocarpa pendula glauca.
Cupressus Lawsoniana.
Eucalyptus viminalis.
Eucalyptus rostrata.
Eucalyptus obliqua.
Eucalyptus pinnata.
Eucalyptus corynocalyx.
Eucalyptus Gunni.
Eucalyptus amygdalina.
Fatsia papyrifera.
Fraxinus quadrangulata.
Gymnacladus Canadensis.
Hicoria alba.
Hicoria pecan.
Juglans nigra.
Juglans Sieboldi.
Juglans Californica.
Juglans (Persian).
Laurus.

Magnolia fetida (grandiflora)
Melia azedarach.
Morus alba.
Morus multicaulis.
Morus Moretti.
Morus Japonica.
Morus Downingii.
Negundo Californica.
Olea Europæa (named vars. and seedlings).
Olneya tesota.
Pinus Austriaca.
Pinus pinaster.
Pinus strobus.
Pinus sylvestris.
Pinus insignis.
Pinus pinea.
Pinus Torreyana.
Pinus Canadensis.
Pinus ponderosa.
Pinus pinsapo.
Pinus Coulteri.
Pinus Veitchii.
Pinus flexilis.
Phyllea latifolia.
Picea pungens.
Populus monilifera.
Prunus ilicifolia.
Pseudotsuga Douglassi.
Quercus robur.
Quercus suber.
Rhus cotinus.
Rhus Sp.
Salix viminalis.
Sequoia sempervirens.
Sequoia gigantea.
Sterculia platanifolia.
Sterculia diversifolia.
Taxus Hibernica.
Tilia Americana.
Tilia argentea.
Thuya occidentalis.
Ulmus racemosa.
Ulmus (weeping).

SANTA MONICA STATION.

The Location.—The Santa Monica Forestry Station represented the most valuable part of the property of the late Forestry Board. Senator J. P. Jones and the Baker family deeded the land to the State, as was previously mentioned, and more land can probably be obtained whenever it is needed. In point of situation nothing could be finer than the way in which the twenty acres which belong to the station lies on four different levels, and as many slopes, between the branches of Santa Monica cañon. There is a marvelous variety of soil and exposures on the tract, and both the upper and middle mesas overlook the ocean, a mile away. From the town of Santa Monica the distance is two miles and a half, upon a great highway, and thousands of visitors drive through the grounds every season. Rustic cañon itself, on the northern side of the tract, will, in time, justify a great deal of wild gardening, and the naturalization of many flowering plants, such as rhododendrons, azaleas, lilies, etc., that love such rich black leaf-mold, shade, and moisture. The various slopes are fitted for an almost endless range of experiments in form and color. The steep, barren cliff, by which the upper mesa of the tract breaks off suddenly into the cañon on the south, is particularly well suited for gorse, broom, laburnum, and golden acacias. This upper mesa contains about ten acres. The middle mesa, on which the main cottage is built, contains about seven acres. The lowest terrace is a little above the creek; and a small terrace, out of which springs flow abundantly, is half way between the lower and the middle terraces. Even in the very bed of the creek itself, a gravel island protected by willows—a quarter acre or so—contains soil enough for tree planting. Nearly all of the slopes are adapted to vegetation. The total of waste land in the tract is hardly worth considering.

The Eucalyptus Collection.—When the University took charge in July, the following 44 species of Eucalyptus were growing on the plantation:

Eucalyptus hemiphloia.
Eucalyptus robusta.
Eucalyptus eximia.
Eucalyptus amygdalina.
Eucalyptus corymbosa.
Eucalyptus cornuta.
Eucalyptus ficifolia.
Eucalyptus siderophloia.
Eucalyptus platypus.
Eucalyptus eugenoides.
Eucalyptus diversicolor, var. colossea.
Eucalyptus goniocalyx.
Eucalyptus tereticornis.
Eucalyptus macrorhyncha.
Eucalyptus pauciflora.
Eucalyptus regnans.
Eucalyptus leucoxylon.
Eucalyptus rostrata.
Eucalyptus viminalis.
Eucalyptus alpina.
Eucalyptus citriodora.
Eucalyptus corynocalyx.
Eucalyptus rudis.
Eucalyptus globulus.
Eucalyptus Stuartiana.
Eucalyptus saligna.
Eucalyptus Gunni.
Eucalyptus pinnata.
Eucalyptus marginata.
Eucalyptus Planchoniana.
Eucalyptus gomphocephala.
Eucalyptus amygdalina, var. angustifolia.
Eucalyptus leucoxylon, var. rosea.
Eucalyptus Lehmanni, var. strieta.
Eucalyptus occidentalis.
Eucalyptus buprestium.
Eucalyptus polyanthema.
Eucalyptus paniculata.
Eucalyptus calophylla.
Eucalyptus melliodora.
Eucalyptus obliqua.
Eucalyptus resinifera.

The labels of many of the above trees were lost, and it cost much labor to determine the species. The trees had in some cases been broken down by cattle, and were nearly flat on the ground. Few of them were in any sense fair specimens.

The Larger Plantations.—On the south side of the middle terrace, at the base of a steep slope, a small grove of choice acacias had been planted. This was very handsome at first sight, as some of the trees were twenty and thirty feet high and their branches interlocked, forming a solid mass of green. Upon examination it was found that in this promising young forest many of the trees had been planted in pairs or triplets, to secure a good stand, but that the surplus plants had not been removed. In consequence, there were numbers of cases in which two or three large, strong acacia trees were twisted and interlocked, roots and trunks, utterly ruining their shapely growth. In other cases cattle had broken down the tops, and the result was a mere thicket, like a tangle of willows in a creek bottom.

From four to fifteen rows of eucalypts had been planted around three sides of the highest bluff, and here, also, the need of thinning was at once manifest, though there were many fine trees, particularly of E. corynocalyx.

Taking Charge of the Station.—The University authorities sent Mr. Julius Forrer, foreman of the station at Tulare City, to Santa Monica at the close of June, with written instructions to take charge of the place, map the grounds, list the trees, and do all that was possible to improve the appearance of things, until a foreman should be appointed for the Forestry Station. The foreman of the late Forestry Board for a time refused to surrender the property. The attorney of the Board of Regents notified him to leave, and meantime Mr. Forrer took possession of the large cottage, while the former foreman occupied the small workman's cottage, where he remained till July 17th. The University therefore was not in full possession of the station until the latter date. The new foreman, W. J. Strachan, appointed from the Experiment Station at Berkeley, had arrived July 13th. On the 19th, Mr. Forrer left the station, having performed a difficult task with tact, firmness, and ability.

Former Improvements and Supplies.—When the University took charge, the improvements on the station tract consisted of a small, old stable; a workman's house of three rooms (worth, perhaps, $400); a large lath-house for plants; two water tanks; a hydraulic ram, and the necessary water pipes. Lastly, there was a foreman's cottage of five rooms, which could be duplicated for about $1,200. This cottage is in a very sightly situation at the seaward end of the middle flat. It contained, when transferred, two oak bed-room sets. A pair of farm horses, the two being worth about $150, were turned over to the University. A farm wagon, a few old tools and farm implements, and a set of harness completed the working outfit. An ample supply of pots, labels, laths, and box materials was on hand. Beyond this, the station had little of any value. The first purchases made by the University were hay and horse-feed, a cart and harness, a cultivator, paint for roofs, shakes to repair the stable, and hand-tools for the workmen.

Reorganization of the Station.—Upon the transferring of the station Mr. Henry W. Kruckeberg, editor of the "Rural Californian," of Los Angeles, was appointed Patron, and has shown himself heartily in accord with the plans of the University. It was of course impossible to

do much to improve the appearance of the station until the rains came. The foreman destroyed weeds, hauled brush, grubbed out stumps, propped up trees in the plantations, and cleared wild land. The upper bluff was broken with four horses and a road plow, harrowed and cross-harrowed. Then it was sown to Nepaul barley, for the double purpose of securing a hay crop and of getting the land into better shape for a future tree plantation. In December four men besides the foreman were actively engaged on the station grounds.

After thinning the eucalyptus plantation in the large oval area south of the cottage (retaining, of course, specimens of every species represented), the acacia grove was thinned and put into shape. The best specimens of trees were selected and open space secured about them. The ground was plowed and stumps and wild growth grubbed out. In a year or two the acacia grove will be a very striking object and some of the wattle bark can be tested for tannin.

Work on the Middle Terrace.—Over the larger part of the middle terrace, east of the cottage and the eucalyptus grove, there has been little planting, and that chiefly consists of the remains of former nursery rows. Half of the eastern end of this plateau was still wild land last July, except for some eucalyptus planted in the brush as an experiment. A portion of it has now been cleared, as it will very soon be needed for new species of trees.

In the old nursery rows, all the trees standing too close for beauty or healthy growth have been removed. An effort is being made to save the camphors which were badly girdled. Three good specimens of Prunus ilicifolia can remain. Two Phyllea latifolia were all that the space would allow. A few trees of Taxodium distichum were badly gophered, and can hardly be saved. Catalpas were abundant, but since they line a part of the main avenue across the grounds, all but one were dug out. Four or five trees of each of the two species of ash were retained. Some butternuts left from an old nursery row were in such shape that five of the best could be kept; the others were moved elsewhere. Good specimens were saved of Acacia retinoides, A. cyanophyllum, and A. longifolia, and also a very pretty and well-grown lot of A. farnesiana. Three good specimens of Quercus cerris, six carobs, a number of mesquite trees (Prosopis juliflora), and a few of the Olneya tesota and Cordia cordata were left in permanent plantation here. At the northern end of this flat were several healthy fruiting specimens of the beautiful pink-flowered Lagenaria Pattersoni. A few plants of walnut, Italian sumac, Sterculia platanifolia, Celtis occidentalis, and one or two other species completed all that this portion of the tract contained. After removing the surplus trees, some were planted on the upper plateau, others on the lowest terrace near the creek, so as to begin a system of comparative tests in different soils and under different conditions.

About thirty black acacias (Acacia melanoxylon) planted as avenue trees on this terrace were so root-bound that they were dying, or could be pushed over by a slight effort. A few of the best were saved for specimens; the rest were destroyed. Fortunately we were able to preserve good trees of all the species of acacia at the station, being more fortunate in this respect than in regard to the eucalypts, for which we had to depend in some cases upon very poor trees of rare species.

The Lower Terrace.—Here we retained a pretty, though long neglected pittosporum hedge by the roadside. Several hedges of Monterey

cypress, which divided and spoiled the small, rich, level surface, were removed, only leaving a few rods at the western entrance to Rustic cañon. Some overcrowded pines and other trees were cut out, in order to save a fine rosewood tree (Jacaranda mimosæfolia), a Hovenia dulcis, and two araucarias. With these changes, this sheltered oval of sandy soil affords room for many more specimens of important and hitherto unrepresented species.

The Workmen's House.—It was decided to use the three-room house above the slope on the lower terrace for a tool and store house, for which it is admirably adapted. The rough board partitions were taken out, large passiflora vines trained over the walls, a number of small garden beds thrown into a few larger ones, and the endeavor made to treat as a united whole the entire slope, the winding road, the creek bluff and margin, and the picturesque level on which the little house stands. In this part of the grounds there are some very fine native elders, sycamores, oaks, heteromeles, etc., which can easily be preserved, and some very sturdy eucalypti have been planted in the edges of the creek and by the turns of the road.

Water Supply.—From beneath the crest of the northern slope of the middle terrace of the tract, in a thicket of California laurel, oak, willow, and blackberry, there is a constant though small flow of water. This was rudely developed some time ago by cross ditches; it is now being developed systematically by two lines of drain tile, with tributary branches on the upper side. The water from this valuable spring is carried across the road to the small cottage, goes into a 2,000-gallon tank, giving it sufficient fall to drive a hydraulic ram which lifts a portion to another tank on the middle terrace. If the lower tank is kept full, 205 gallons of water can be delivered 12 feet above the base of the upper cottage in one hour and five minutes. The ram is supplied through a 3-inch pipe 119 feet long, having a vertical fall of 12 feet 5 inches. The waste water is of some use for irrigation in the cañon. The system is cheap and probably will supply all the water needed for the house and garden. At one time there was a flume extending up the cañon, so as to increase the supply to the ram, but this, not being secured in any manner, was washed out by the winter freshets. It is believed that the springs on the tract will furnish an ample supply. The tanks have been pumped out and cleaned of a foot or two of debris and sediment. A good deal of inch pipe was formerly laid in the nursery and in other parts of the grounds. With some needed changes the water system will probably prove reasonably satisfactory. It must be understood that trees on the highest plateau must always be grown without irrigation, trees on the middle terrace can receive if necessary a little water while small, but the lower terrace can be fairly well irrigated in case of need.

Additions to the Plantations.—In many cases species already planted in one place have also been planted in other plateaus of the tract. In addition to whatever has been mentioned in the preceding pages, as found on the grounds when the University took charge, there are now representatives of the following species in the plantations, besides others not yet placed in permanent form:

Palms.

1 Phœnix reclinata.	1 Sabal palmetto.	1 Chamærops excelsa.
1 Phœnix Canariensis.	1 Kentia Fosteriana.	1 Areca Baueri.
1 Phœnix tenuis.	1 Kentia Balmoreana.	1 Dracena draco.
14 Phœnix dactylifera.	1 Kentia Canterburyana.	

Oaks.

30 Quercus pedunculata.
2 Quercus rubra.
4 Quercus suber.

Evergreens. (Broad-leaved.)

1 Cinnamonum Loureiroi.
1 Oonshiu orange.
2 Aberia kaffra.
1 Buxus aurea.
1 Buxus sempervirens.
2 Psidium Cattleyanum.
1 Pittosporum rugosum.
1 Litchee.
Ilex (in variety).
1 Photinia eriobotrya.
1 Melaleuca.
1 Lycium Andersoni.
1 Lytrs caustica.
1 Edwardsia McNabiana.

Evergreens. (Conifers.)

1 Sciadopythis verticillata.
2 Cryptomeria Japonica.
1 Retinospora ericoides.
1 Araucaria Braziliensis.
2 Larix Americana.
2 Larix Europæa.
1 Pinus ponderosa.
1 Pinus pinsapo.
1 Pinus Canadensis.
1 Abies Veitchii.
1 Abies Menziesii.
2 Taxus Hibernica.

Bamboos. (In variety.)

Vines and Trailers.

Stauntonia hexaphylla.
Tecoma jasminoides.
Mandevillia suaveolens.
Cobœa scandens.
Climbing roses.
Trailing cypress.

There are also small specimens of many other evergreens still in pots or in the nursery.

Deciduous Trees and Shrubs.

1 Acacia julibrissin.
2 Castanea vesca.
2 Castanea sativa.
1 Liriodendron tulipifera.
1 Liriodendron integrifolium.
1 Malus carda.
1 Juglans regia.
1 Juglans regia (variety Kaghazi).
1 Juglans Sieboldi.
2 Gleditchia tricanthos.
1 Fraxinus excelsa.
2 Fraxinus Americana.
2 Fraxinus Ornus.
2 Fraxinus (water ash).
2 Sorbus Europæa.
1 Colletoa spinosa.
1 Kolreuteria paniculata.
6 Pyrus Japonica.
Morus in variety.
1 Elæococca cordata.
2 Eleagnus longipes.
100 Betula alba.
2 Betula nigra.
2 Prunus serotina.
2 Prunus spinosa.
2 Acer campestre.
2 Acer saccharinum.
2 Acer plantanifolium.
1 Caragana arborescens.

III.

REPORTS ON ENTOMOLOGY AND PLANT DISEASES.

A Laboratory of Plant Diseases.
Root Knots on Fruit Trees and Vines.
Experiments in Winter Spraying of Apples and Pears.
Remedies for Plant Diseases.

REPORTS ON ENTOMOLOGY AND PLANT DISEASES.

A LABORATORY OF PLANT DISEASES.*

By C. W. Woodworth.

There has recently been equipped at the University of California a laboratory for the study of the subject of plant diseases in its broadest sense; and as there are but few if any others where the subject is taught as a unit, it may be well to give an outline of the equipment for this class of work.

We will not consider that part of the equipment for the work afforded by the grounds, orchard, nursery, gardens, and greenhouses of the Agricultural Department, but confine ourselves to the laboratory proper. The subject of plant diseases is now and will continue to be associated with that of entomology, so that the same equipment, to a considerable extent, serves for the two subjects.

The laboratory room is something over 20 by 30 feet, and is situated on the north side of the Experiment Station building. It is lighted by four windows, having an entirely unobstructed view, and so giving ample light for microscope work. A corner of the room is partitioned off for a private laboratory, and a closet is fitted with a ruby window, affording an opportunity for photo and blue print work.

The windows are all fitted with heavy shades working in grooves, enabling one to darken the room very easily and quickly when the lantern is to be used for illustration. The views are projected on a screen of tracing cloth, which is mounted on a common spring-roller and is ordinarily rolled up out of the way.

Besides the benches near the windows, which are used by advanced students, there are also three long desks, 1½ feet wide by 12 feet in length. These are so constructed that at the side of each student, boxes, the size of those in the collection, may be used as drawers, or boards may be inserted, forming shelves.

The boxes used for the collection are so made as not to be liable to warp or crack, and so remain perfectly insect proof. A cloth bearing for the glass is treated with corrosive sublimate, and the paste and glue used are arseniated. These boxes are kept in cabinets, the glass doors of which are fitted with a rabbeted groove on all four sides, thus making them also dust and insect proof.

The collection kept in these cabinets are arranged in three series. Series one is the systematic collection where the organisms producing injuries are grouped in the ordinary order, beginning with mammals and ending with the highest plants. The second series is the "host" collection, where the various plants are taken up in an agricultural order, as, for instance, seed crops, fruit crops, etc., and the injuries to each peculiar crop illustrated. In the third series, the symptomatic

* Science, December 30, 1892.

collection, all diseases having a common symptom are brought together, thus all galls and the distortions, from whatever cause or on whatever plant, are assembled and classified.

Besides these there are the beginnings of a cryptogamic herbarium in drawers, and a collection representing the materia medica of plant diseases. There are in the laboratory a sterilizer and all the other necessary apparatus for this class of bacteriological work. For microscopical and histological work there is also a good equipment, including paraffin bath, microtome suitable for the highest grade of work, compound microscopes and accessories, and a very good outfit of reagents. All reagents, as far as possible, are kept in standard strengths, and the bottles marked to serve as graduates for dilution. Thus the chromic acid is made up in a large bottle into a 5 per cent solution. The 1 per cent solution is made by filling a smaller bottle to a certain mark and adding water. Most of the chromic mixtures are made from the 1 per cent. The chromic-acetic killing mixture, for instance, is made as indicated on the label: from one half per cent chromic acid to the first mark, 95 per cent alcohol to the second, and 10 per cent acetic acid to the neck. Mixtures liable to deterioration are kept in very small bottles, and such as the acid alcohols are not kept mixed at all, but large homo vials are properly labeled and graduated and the mixtures made up as used. This sketch gives merely the present condition of the laboratory. It is expected that apparatus will be added from time to time, as opportunity offers, and as it is needed for the work in hand; indeed, there is considerable new apparatus at the present time being constructed for the laboratory.

ROOT KNOTS ON FRUIT TREES AND VINES.

By C. W. Woodworth.

Introductory Note.—The subject upon which Professor Woodworth makes the following interesting statement has perplexed California fruit-growers for many years. Almost everything imaginable has been cited as a probable cause; conditions of drought or of excessive moisture were among the earliest causes assigned, and some prejudice against nursery stock grown by irrigation was created. An investigation by a committee of the State Horticultural Society about 1880 showed that the knotted roots were found quite as abundant in unirrigated land as in irrigated, and otherwise the inquiry yielded no definite results. For some time many nurserymen followed the practice of removing the knots from the trees as dug from the row, but this was abandoned when it was found that the knot commonly reappeared after planting in the orchard. At present no reputable nurseryman sells such trees; they are burned at the nursery.

In my personal examination of knots, which has continued for fifteen years, I have but on one occasion found a nematode gall, and that was upon the root of an English walnut sent from Los Angeles County. Nearly all the others were of the character described by Professor Woodworth as "crown galls," although they are found in many cases farther down on the roots. Some orchardists have been at great expense in laying bare the roots and smoothly paring them and applying various substances to the wound. In most cases the knots have reappeared subsequently. Others have laid bare the knot-burdened root-crown to the sun and the knots have flaked off, but other knots have been found afterward lower down on the roots.

It must be acknowledged that the cause of the evil and its cure are still unknown, and it is to be hoped that Professor Woodworth's study of the subject, which is still in progress, may reach definite conclusions. His advice not to plant a diseased root should be zealously adhered to by all planters. Probably during the last twenty years, hundreds of thousands of such trees have spindled and died in the best soil and with the best treatment. If the disease has stunted the growth of a young tree, pluck it out and plant a new one. If knots are found on larger trees, which are making satisfactory growth in spite of them, remedial measures should be tried. The final result seems to depend upon whether the natural or diseased growth secures the ascendency early in the life of the tree, for apricot trees have been taken up after thirty years of satisfactory growth and bearing, and found to have roots badly infested with the knots. (E. J. Wickson.)

Distribution.—There is no one thing about which so many inquiries have been received as a peculiar form of root knot or gall on a number of plants, chiefly grape and apricot. It seems to be much more injurious in this State and in Arizona than elsewhere, though it occurs in all parts of the country and in Europe, more or less abundantly. These knots are of irregular shape, fleshy and mostly situated at or about the crown of the roots. On different plants they present a somewhat different appearance, but they are so near alike in structure as to prove that they must all be due to practically the same causes. I have studied the gall on apple, peach, plum, prune, apricot, cherry, grape, blackberry, and hop.

Confusion of Names.—This form of gall has received a number of local names, the most widely used of which is that of "black knot," particularly for the form that occurs on the grape. Since the publication of Bulletin No. 99 by this Station, the subject has been much discussed in horticultural societies and in the press of the State, and the term black knot has been quite generally adopted. This name is objectionable, as was there pointed out, as it has long been used in the Eastern States for a very different kind of gall that occurs on the stems of cherries and related fruits; and, moreover, our knot is not black but light brown at first, becoming dark brown, but never black. On account of its presence almost always at the crown of the root, the term crown gall or knot was suggested, and is a good name, as other forms of gall seem to show as decided a preference for other parts of the root as this does for the crown.

The Crown Gall.—The crown gall is by no means invariably at the crown. They are often very abundant at the point where the roots were cut by the digger when they were removed from the nursery, or where they were bruised in setting. Insects may also cause the appearance of the crown gall lower down on the roots, as will be shown below. The crown knot only appears below the service of the ground, so far as known, except in the grape, where it is sometimes just above the ground. Some forms of excrescences occurring on the trunk and branches have often been supposed to be the same as the crown knot.

Galls above Ground.—The following have been confused with the crown knot:

(1) *Mechanical galls*, which are slight swellings produced in the healing of wounds, or where repeated bruisings occur, as in case of crossed limbs. They generally have a smooth surface, which will at once distinguish them from crown knots; and the structure is entirely different.

(2) *Gnarls*, which while small consist of a free, hard, woody kernel beneath the bark, but later become attached to the wood of the trunk and ultimately disappear through the growth of the trunk. They are generally explained as being latent buds which have started to grow, but perhaps from the death of the axial cell have been unable to produce a shoot, but continue to grow and make wood. The cause or condition of their production is a matter of which we are quite ignorant, but as to their difference from the crown knot there is no doubt, and structurally they have scarcely anything in common.

(3) *Twig galls*, found on many plants, especially the quince, where they are so uniformly present as to be generally regarded as normal structures. They are generally smaller than the crown knots and much

rougher, and differ in their manner of growth, appearing hard from the first.

The crown galls arise generally from one side of the crown as a simple swelling of fleshy substance of about the consistency of a potato, or perhaps somewhat harder. They soon become irregularly granular over the surface and dark brown in color, the outer parts of the granulations into which the surface is divided being the darkest. When cut or broken open they are almost white at first, but very soon become reddish brown on exposure to the air. Under the microscope they may be seen to be composed of large, thin-walled cells, with now and then the distorted and scattered elements of the fibro-vascular bundles.

A young gall of this kind contains very much water, and if dried becomes sponge-like and is very light, though quite hard and often cracked radially. When attacked by fungi while still young the knot will take on this appearance after a time. Older knots are harder, and dry into harder and firmer masses, which do not shrink or become sponge-like. In size the crown gall varies greatly, being often as large as one's fist and sometimes much larger, especially in the apricot.

Other Root Galls.—Of other root galls, we may distinguish five different kinds:

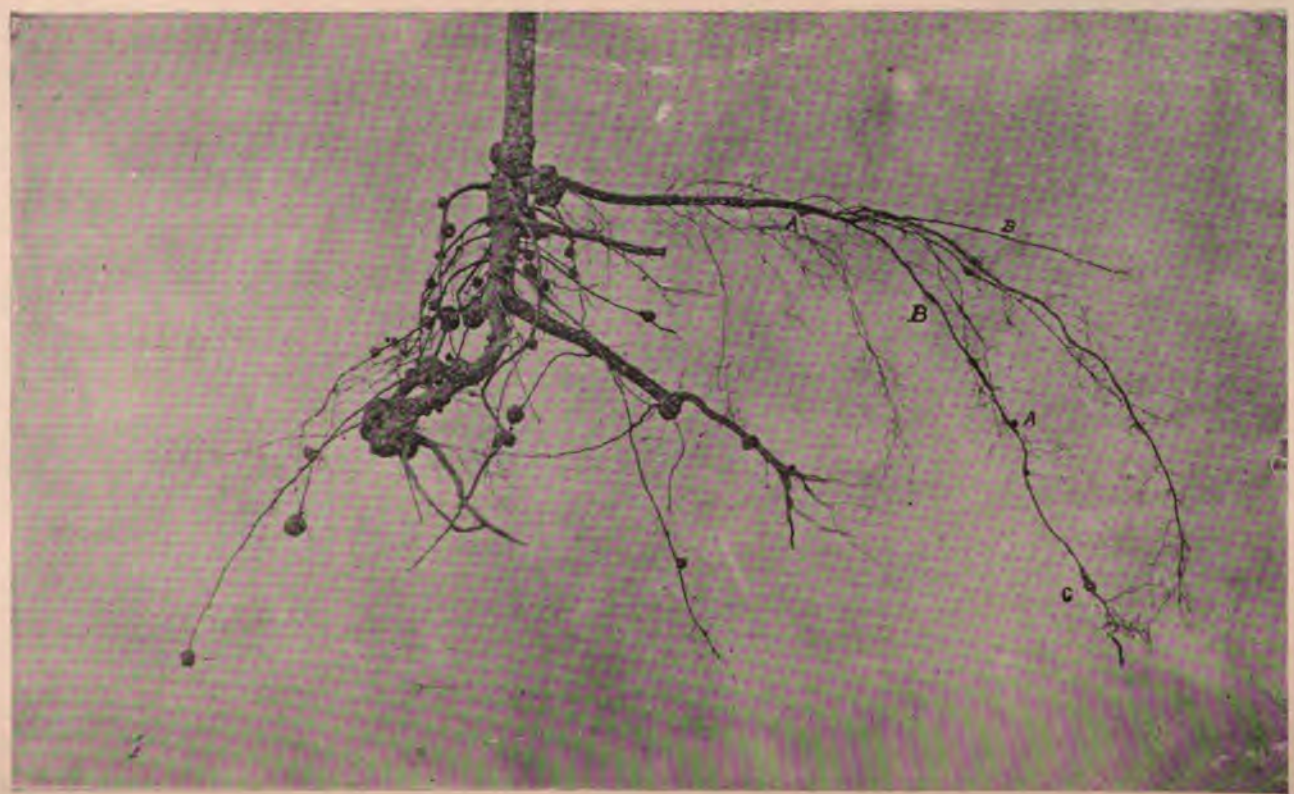
(1) *Mechanical galls*, which are slight swellings, sometimes produced at points where the roots meet obstructions, and are quite common on the roots of some plants in a stony soil. They may be told at once from a crown gall by their comparatively smooth surface, and by the fact that they only accompany an abrupt bend of the root. They are only slight swellings and flattenings of the root, and are seldom found anywhere near the crown. Indeed, they are the form of root gall least likely to be mistaken for the crown gall.

(2) *Louse gall*, due to the attacks of plant lice. Those caused by the phylloxera and woolly aphis are well-known examples. They are almost always of small size, occurring on both large and small roots, and as often at the crown as elsewhere. The presence of the lice is generally sufficient as a distinguishing character, though their small size may render them hard to be seen.

(3) *Tubercle galls*, found only on the roots of plants of the pea family. Only the smaller roots are affected. The gall is about an eighth of an inch or less in diameter, the whole inside of which is swarming with minute moving particles, which appear to be bacteria. They play an important rôle in the acquisition of nitrogen from the air by the plant. The small size of these galls and their presence only on the small roots will distinguish them from the crown galls.

(4) *Club-foot galls*, produced by a slime-mold (*Plasmodium brassicæ*), on the roots of cabbages and similar plants. These galls are somewhat yellowish when broken open, which color is due to the presence of the slime-mold in great abundance in the diseased tissues of the gall. They may be distinguished from the crown galls by not being so knot-like, but being much more closely attached to the plant.

(5) *Nematode galls*, which are due to minute worms resembling very much the so-called vinegar eels. They are found on the roots of a great number of plants. The worms are so small that ordinarily they will not be seen without examining sections under the microscope. The small size of the gall, and its presence chiefly on the smaller roots, will distinguish it from the crown gall.



APPLE ROOT, showing Crown Knot (AA), Woolly Aphis Galls (BB), and a Gall (C), illustrating both forms.

Cause of Crown Gall.—There are several theories as to the cause of the crown gall, but none of them are without very serious objections. One idea is that these galls are the result of wounds made in cultivation, and there is no doubt but that the galls have followed such wounds. In attempting to heal a wound, as is well known, the plant will often produce at that point a slight swelling, and it is argued that at the crown the conditions are such that a large swelling will result. There are, however, a number of fatal objections to this hypothesis. Neither is the crown gall the uniform result of a wound; nor is a wound, at least one made by human agency, necessary to produce a gall, though it would be bold to assert that there had never been a wound of any kind at the point where the gall is produced. The most fatal objection to this hypothesis is the fact that the appearance, the manner of growth, and all the phenomena connected with the crown gall are so different from those of a healing wound that there seems scarcely any reason to connect the two.

Another theory is that they are due to peculiar conditions of the weather, such as frosts, excessive rains, and such things at a critical time in the spring; these cause an abnormal stagnation or an excessive flow of sap, and the gall is the result. It is a well-known fact that excessive sap pressure will produce abnormal growth of parts of the plant, but nothing comparable with the crown knots. Indeed, these suppositions are scarcely reconcilable with the facts of plant physiology, and it has never been observed that these galls are produced in particular abundance immediately following any peculiar spring condition. It would seem that the idea arose from the general tendency to ascribe every abnormal condition of a plant to the weather.

A third theory is that they are due to some of the fungi related perhaps to that which produces the true black knot. The only objection to this theory is that no such fungus has ever been observed about the knots, at least not in the living knots, and it may be that a more careful study than has yet been made will show that such fungus does occur.

Finally, as has become quite the fashion of late years, the bacteria have been charged with the injury. I myself have succeeded in getting pure cultures of a micrococcus from the inside of some of the knots, after taking all the usual precautions to prevent accidental contamination. This, however, is by no means conclusive, but there is a great deal of evidence that the gall is an infectious disease of the plant. The accompanying figure is from a photograph of the roots of one of a number of similar young apple seedlings grown in the University nursery. It was badly infested with woolly aphis, but the galls upon which they lived were not like those generally produced by this insect, but were in every respect true crown knots. The seedlings were two years old and transplanted when one year old. At this time they were free from the aphis, but some had the knots at the crown. After they became infested with the aphis those having old crown knots became knotty all over the roots, as in the one photographed. To make the evidence still more striking, a very few of the galls were typical woolly-aphis galls, and these were in every instance in such a position that the lice would have naturally reached the spot in walking down the stem without coming in contact with the gall. Galls of this kind are shown at BB, typical crown knots at AA, and at C one that in part resembles the crown knot

and in part the woolly-aphis gall. In another specimen the woolly-aphis gall occurred only on a root given off above the knot.

Effect of Crown Knot.—The presence of a gall at the crown while it remains alive seems to affect the plant but very little, but later it will produce injury in one or two ways: First, the gall presenting a mass of dead tissue for the various semi-saprophytic fungi which only seem able to become parasitic after gaining a foothold in some dead tissue, and so become able to overwhelm the plant; or second, the dead gall, if not too deep below the surface of the ground, will dry out, as will the adjacent parts of the stem. If this drying process proceeds beyond a certain point the water supply for the leaves will be insufficient, and the plant will die as if by drought. The gall generally attacks small plants, but not always, and it often takes a number of years before the plant is killed.

The crown knot has come to have a legal aspect through the work of the Horticultural Commissioners. Nursery stock which is attacked by the knot is condemned and destroyed. In addition to this it would be well if it was required to dip in Bordeaux mixture all stock which has come in contact with knotty trees, as it is probable, though not certain, that the disease may be conveyed in this way. It is quite certain that tools used in digging do convey the disease.

Remedies Suggested.—Whatever the cause, many fruit-growers in California have had reason to know the seriousness of the injury produced, so the following words in regard to remedies and prevention will not be out of place. A number of experiments that have come under my observation go to show that the knots can be successfully removed from trees in the orchard when they occur only at the crown. Care must be taken to treat all places touched by the hoe in unaffected trees examined, as well as those from which the knots are removed. The following treatment is recommended:

First—In the orchard the knots should be carefully removed and burned as soon as found, and an antiseptic application made to the tree where the knot has been removed. We would recommend Bordeaux mixture for this purpose. Trees so treated should be examined from time to time for at least a year, and should the knot reappear, it would be best to remove and destroy the whole tree. When a tree is removed, it would be well to delay resetting for a year or two, or to reset with a tree of an unsusceptible kind.

Second—When setting an orchard, reject all stock affected by the knot. I would prefer to have stock from a nursery known to be entirely free from it, though I have reason to believe that no nurseries in this State are absolutely free from it. It would be a good plan to dip all the trees in Bordeaux mixture before setting.

Third—In the nursery the greatest care should be taken to destroy by burning everything showing any sign of the disease, and the dipping of all stock in Bordeaux mixture as soon as dug is recommended. Fields in which these galls have appeared should be devoted to some other crop for a number of years.

EXPERIMENTS IN WINTER SPRAYING OF APPLES AND PEARS.

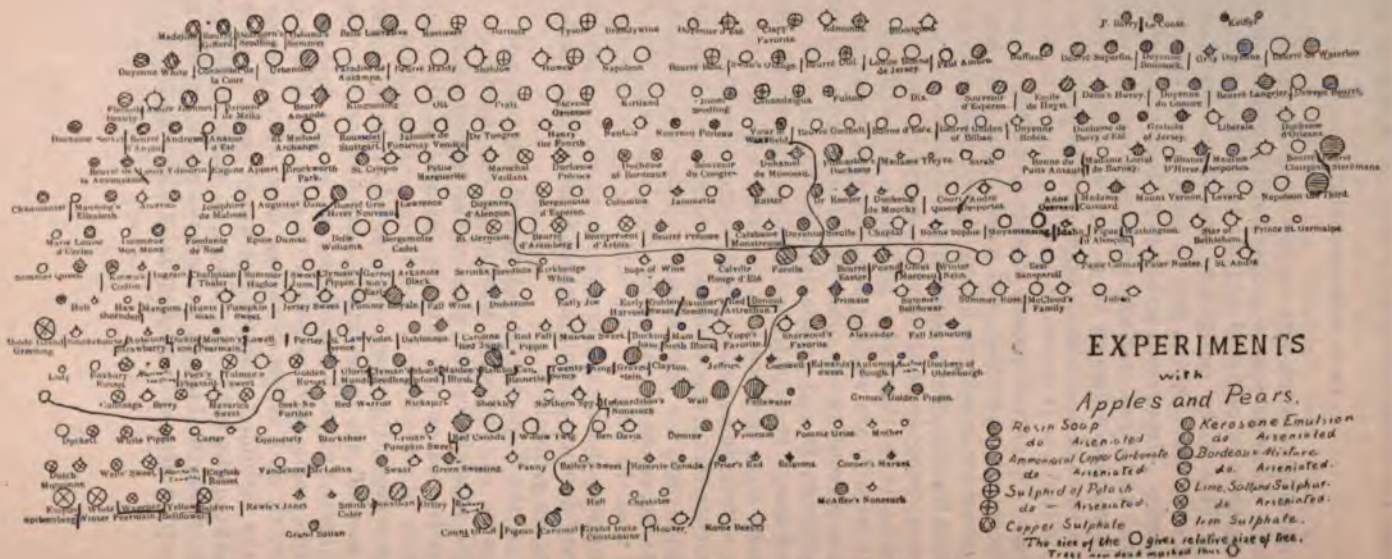
By C. W. Woodworth.

The ranch of a generation ago in becoming the farm or orchard of to-day retains its old name and to a considerable extent its old practices. As the sheep began to be replaced by fruit trees the old sheep-dip became the tree-wash. This is the pedigree of one of our standard washes, the lime, salt, and sulphur mixture, and in this case it has proven itself a very useful remedy. The present article is written as a protest against the blind use of this and other washes inherited from other days, for as the sheep were all regularly dipped so it is the common practice in this State to apply a wash of some kind, upon general principles, each winter or spring, while the tree is dormant, with no regard to the condition or need of the tree. Venders of patent washes and often horticultural commissioners advocate this practice, and many among the most progressive fruit-growers consider it safer to follow the custom, though orchardists are by no means unanimous in their approval of it.

There are many who do not believe in spraying trees at all, including those too lazy to do so, those who believe in the sufficiency of natural checks, and those who are waiting for imported parasites; and on the other hand as representing the other extreme, there are many who wash their trees persistently and regularly, believing that in this way only can insects and fungi be kept from becoming excessively abundant and injurious, or who have the idea that the wash acts in some way directly on the tree as a medicine, making the tree more healthy.

The experiments herein reported were undertaken under the impression that the common practice was sound, and the object was to compare a number of washes, especially those commonly used in this State and in the East, and also the effect of the addition of arsenic to the washes. For these purposes these experiments were entirely negative in their results, but they do show plainly certain facts bearing upon the question of tree washing in general.

Description of the Experiments.—A plot of the orchard in which the experiments were conducted is shown in the accompanying figure, which will give at a glance the plan of the experiments. The size of the trees as indicated on the plot by the size of the circles will give quite accurately their physical condition, except that some of the smaller circles represent young trees instead of decrepit old ones. The trees marked as dead are those which have died or have been removed on account of their unhealthy condition up to the date of this report. This loss of trees seems to have been in a good part due to injury to the bark of the trunk and larger branches done when the strong caustic washes were the fashion. Among the apple trees another cause also operated in making the heavy mortality. Certain of the common toad stools gaining entrance through the excrescences on the roots caused by the woolly aphis were able to effectually kill many of the trees. The



Plot of the Orchard at the Experiment Station, Berkeley.

relation of this mortality to the treatments is a matter of some interest and is shown in the following table:

	Treated.			Untreated.			Total.		
	No. of Trees.	No. Dead.	Per cent Dead.	No. of Trees.	No. Dead.	Per cent Dead.	No. of Trees.	No. Dead.	Per cent Dead.
Apples	104	32	30	96	39	40	200	71	35
Pears	117	23	20	148	35	24	265	58	22
Totals	221	55	24	244	74	30	465	129	27

The decidedly less amount of death in the treated trees is not to be explained as the result of the treatment, but the difference is caused by the fact that the worst trees were always left untreated. This is easily proven, since of 72 varieties selected at the time the application was made, in which the two trees of each variety were to all appearances in equally good condition, and in which one was treated and the other left untreated as a check, exactly one half of those that died were treated and one half untreated; that is, of 72 treated trees 20 died, and of 72 untreated trees of the same varieties 20 also died.

The following tables give in detail the records of the experiments:

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES.

Name.	Record Before 1892.			Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.		Woolly Aphis. 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Grand Sultan				good	fair	AACC	good	small	fair	good	none	none
Count Orloff	small	much	small	good	little	ABM	good	good	little	good	little	little
Pigeon				good	little	ABM		good	little	good	little	little
Cardinal	fair	little	small	good	little	ABM		good	little	good	fair	little
Grand Duke Constantine	small	much	fair	good	little	none		fair	fair	good	fair	fair
Hoover*						none	few	good	fair	good	fair	little
Hoover*						none	few	good	fair	dead		
Rome Beauty*	fair		small	good	fair	none	good	good	fair	good	fair	fair
Rome Beauty*	fair		small	good	little	none	good	good	little	dead		
Esopus Spitzenberg	good	little	small	good	fair	LSS		good	fair	good	fair	fair
White Winter Pearmain	strong	little	good			LSS		good	little	good	fair	fair
Wagener	fair	little	small	good	little	LSS		good	little	good	little	fair
Yellow Bellflower	strong	much	small	good	fair	LSS		good	little	good	little	fair
Baldwin	fair	little	small	good	fair	LSS		good	little	good	little	fair
Rawle's Janet						AACC		good	little	dead		
Smith's Cider	strong	none	good	good	little	AACC		good	little	dead		
Smith's Cider	strong	none	good	good	little	AACC		fair	little	good	little	little
Jonathan				good	fair	AACC		good	fair			
Ortley	fair	much	good	good	fair	AACC	fair	good	fair	good	fair	fair
Roxbury Russet	strong	much	good	good	little	none	good	good	fair	dead		
Northern Spy				good	fair	ABM	good	good	fair	dead		
Hall	small	bad	fair	good	fair	ABM	fair	good	little	dead		
Chestatee				good	little	none	little	good	fair	good	none	none
Chestatee				good	little	none	little	good	little	good	none	none
McAffee's Nonesuch				good	fair	ARS	heavy	good	fair	good	little	fair
McAffee's Nonesuch						none		good	fair	dead		
Dutch Mignonne	fair	much	good	fair	fair	LSS		fair	fair	good	fair	fair
Dutch Mignonne	fair	much	good	fair	fair	LSS		fair	fair	dead		
Wells' Sweet				good	fair	LSS		good	fair	good	fair	fair
Wells' Sweet				good	fair	LSS		good	little	dead		
Marshall's Lewelling†				good	little	LSS		good	little	good	little	little
English Russet	fair		small	good	fair	none	fair	good	fair	good	little	fair
Vandevere	strong	little	fair	good	fair	none	good	fair	fair	good	fair	fair
McLellan				good	much	ACC	heavy	good	much	good	fair	little

Swaar	good	little	fair	good	fair	ACC	.....	good	fair	good	fair	fair
Swaar	good	little	fair	good	little	none	.....	good	little	dead	.....	.....
Green Sweeting	.....	.....	.....	fair	little	BM	.....	fair	fair	dead	.....	.....
Fanny*	fair	much	fair	good	fair	none	good	fair	fair	dead	.....	.....
Fanny*	fair	much	fair	good	fair	none	fair	fair	fair	fair	good	fair	little
Bailey's Sweet	.....	.....	.....	good	little	none	.....	good	little	good	little	fair
Reinette Canada	fair	little	fair	.....	.....	KE	.....	poor	little	dead	.....	.....
Reinette Canada	fair	little	fair	good	little	KE	.....	fair	little	good	fair	little
Prior's Red	.....	.....	.....	good	little	KE	good	fair	much	good	fair	fair
Prior's Red	.....	.....	.....	good	little	KE	.....	good	fair	dead	.....	.....
Belmont	fair	bad	small	good	little	ARS	.....	good	little	dead	.....	.....
Cooper's Market	.....	.....	.....	good	fair	ARS	little	good	fair	good	little	fair
Cooper's Market	.....	.....	.....	good	little	ARS	.....	good	fair	dead	.....	.....
Duckett	fair	little	good	good	little	none	good	good	fair	good	little	fair
Duckett	fair	little	good	good	little	LSS	heavy	good	little	good	little	fair
White Pippin	fair	.....	small	good	fair	LSS	heavy	.....	.....	good	little	fair
White Pippin	fair	.....	small	.....	.....	LSS	heavy	fair	fair	dead	.....	.....
Carter	.....	.....	.....	good	little	none	.....	good	little	good	little	fair
Carter	.....	.....	.....	good	fair	none	.....	good	fair	dead	.....	.....
Equinetely	fair	much	good	good	little	none	little	good	little	good	little	fair
Equinetely	fair	much	good	good	little	ACC	little	good	little	dead	.....	.....
Blackshear	.....	.....	.....	good	little	ACC	.....	good	little	dead	.....	.....
Lyman's Pumpkin Sweet	.....	.....	.....	good	little	none	.....	good	little	good	fair	fair
Lyman's Pumpkin Sweet	.....	.....	.....	good	little	none	.....	.....	.....	dead	.....	.....
Red Canada*	.....	.....	.....	good	little	BM	.....	good	little	dead	.....	.....
Red Canada*	.....	.....	.....	good	little	none	.....	fair	little	good	little	fair
Willow Twig*	.....	.....	.....	good	little	none	.....	good	fair	good	little	fair
Willow Twig*	.....	.....	.....	good	fair	none	.....	good	fair	dead	.....	.....
Ben Davis*	fair	bad	small	good	much	none	good	good	much	good	little	little
Ben Davis*	fair	bad	small	good	fair	none	good	fair	fair	dead	.....	.....
Domine	.....	.....	.....	good	fair	KE	small	good	little	good	fair	little
Fameuse*	.....	.....	.....	good	fair	none	fair	good	fair	dead	.....	.....
Fameuse*	.....	.....	.....	good	fair	KE	fair	good	fair	good	fair	fair
Pomme Grise	.....	.....	.....	.....	.....	none	.....	dead	.....	dead	.....	.....
Pomme Grise	.....	.....	.....	.....	.....	none	small	.....	.....	good	fair	fair
Mother	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Mother	.....	.....	.....	.....	.....	none	.....	.....	.....	good	fair	fair
Golden Russet	.....	.....	.....	.....	.....	none	.....	good	fair	good	little	fair
Cullasaga	.....	.....	.....	good	fair	LSS	small	fair	fair	good	little	fair
Berry*	strong	much	fair	.....	.....	none	good	good	fair	dead	.....	.....
Berry*	strong	much	fair	good	little	LSS	fair	good	fair	good	little	fair
Maverack Sweet*	.....	.....	.....	.....	.....	none	.....	good	little	dead	.....	.....
Maverack Sweet*	.....	.....	.....	.....	.....	LSS	.....	none	fair	good	fair	fair
Seek No Further*	fair	much	small	.....	.....	none	.....	.....	.....	good	fair	fair
Seek No Further*	fair	much	small	good	bad	ACC	.....	good	bad	dead	.....	.....

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES—Continued.

Name.	Record Before 1892.			Condition, Spring of 1892.		Treatment, 1892.	Yield, 1892.	Condition, Spring of 1893.		Condition, Spring of 1894.		Woolly Aphis, 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Red Warrior*				good	little	ACC				good	fair	fair
Red Warrior*						none				dead		
Nickajack*	strong	much	fair	good	fair	ACC		good	fair	dead		
Nickajack*	strong	much	fair	good	little	none		none	bad	good	fair	fair
Shockley				good	little	BM		good	little	dead		
Shockley				good	fair	none		good	fair	dead		
Northern Spy*				good	fair	none	good	good	fair	good	none	none
Northern Spy*				fair	fair	none	good	fair	fair	dead		
Hubbardston's Nonesuch	strong	bad	small	fair	fair	KE		none	fair	good	fair	little
Wall*				good	much	KE		fair	much	dead		
Wall*				good	much	KE		fair	much	good	fair	fair
Fallawater				fair	fair	KE	good	fair	fair	dead		
Fallawater						RS				good	fair	fair
Grimes' Golden Pippin	fair		small			RS				dead		
Grimes' Golden Pippin	fair		small			RS				good	fair	bad
Lady				fair	little	none		fair	little	good	little	fair
Roxbury Russet*	strong	much	good	good	fair	none	good	good	fair	good	fair	fair
Roxbury Russet*	strong	much	good			LSS	good	good	fair	dead		
Marshall's Seedling†				good	little	LSS		good	little	good	none	none
Peck's Pleasant				fair	fair	LSS		good	fair	good	little	bad
Talman's Sweet*	fair		small	good	little	LSS	little	good	little	good	fair	little
Talman's Sweet*	fair		small	fair	little	none		fair	little	dead		
Golden Russet*				good	fair	LSS	good	good	fair	good	little	little
Golden Russet*				good	fair	ACC		good	fair	dead		
Gloria Mundi						none		good	little	good	fair	fair
Clyman's Seedling				good	fair	ACC		good	fair	good	fair	fair
Shackleford†				fair	little	none		fair	little			
Maiden's Blush	fair	much	fair	fair	fair	none	little	good	fair	good	fair	fair
Rambo	strong	much	small	fair	fair	BM		fair	fair	good	little	fair
Canada Reinette	fair	little	fair	good	little	none		none	fair	good	little	little
Twenty-Ounce	small		fair	good	fair	none		fair	fair	good	fair	fair
King				good	little	KE		fair	fair	good	fair	fair
Gravenstein				fair	fair	KE	heavy	fair	fair	good	fair	little
Clayton						KE		good	little			
Jefferis				good	little	KE		good	little	good	fair	bad
Jefferis						KE		good	little	dead		

Cogswell	fair	much	small			RS				dead		
Cogswell	fair	much	small			RS				good	little	fair
Edward's Sweet						RS						
Autumn Bough						RS				good	little	fair
Australian						RS		good	little			
Duchess of Oldenburg	small	bad	good			RS				good	fair	little
Rhode Island Greening	strong	little	heavy	good	little	ALSS	heavy	good	little	good	little	fair
Smokehouse*	strong	little	good	good	fair	none	fair	good	fair	dead		
Smokehouse*	strong	little	good	good	fair	none	fair	fair	fair	good	fair	bad
Autumn Strawberry	fair	much	fair	good	small	none		small	little	dead		
Dickinson				fair	little	none		fair	little			
Morton's Pearmain				good	little	LSS		fair	little			
Lowell	fair		small	fair	little	LSS	fair	fair	fair	good	fair	fair
Porter	fair	little	fair	good	fair	none	good	good	fair	good	fair	fair
St. Lawrence				good	little	none		none	fair	good	fair	fair
Violet						none						
Dahlonega*	fair		good	fair	little	ACC		fair	little	good	fair	little
Dahlonega*	fair		good			ACC		good	fair	dead		
Carolina Red June	fair		small	fair	little	none	fair	fair	little	good	fair	little
Red Fall Pippin*	fair	little	good	good	little	none		good	little	good	fair	fair
Red Fall Pippin*	fair	little	good	good	fair	none		good	fair	dead		
Munson Sweet*						none				dead		
Munson Sweet*				fair	fair	KE		fair	fair	good	fair	fair
Buckingham				good	fair	KE		good	fair	good	fair	fair
Mammoth Black				good	little	KE		good	little			
Yopp's Favorite*	fair	much	fair			none		good	little	dead		
Yopp's Favorite*	fair	much	fair	good	little	RS		good	fair	good	fair	little
Sherwood's Favorite*	good		fair			none				dead		
Sherwood's Favorite*	good		fair	good	little	RS		little	fair	good	little	fair
Alexander*						none	good			good	fair	fair
Alexander*						RS	good			good	fair	fair
Fall Jenneting*						none				good	fair	fair
Fall Jenneting*						RS				dead		
Hall	small	bad	fair	fair	fair	ALSS	good	fair	fair	good	fair	little
Hall	small	bad	fair			none	fair			dead		
Hawthornden	fair	much	good			none	fair	good	little	good	fair	little
Mangum	fair	much	small	fair	little	none				good	fair	fair
Huntsman				fair	little	none		good	fair			
Pumpkin Sweet*	strong	much	small	good	fair	none	good	none	fair	dead		
Pumpkin Sweet*	strong	much	small	good	fair	none	good	fair	bad	good	little	little
Jersey Sweet*	fair	bad	fair	good	much	none	fair	small	much	dead		
Jersey Sweet*	fair	bad	fair	fair	fair	none		fair	fair	dead		
Pomme Royal*	fair	little	small	good	little	none		good	little	good	little	fair
Pomme Royal*	fair	little	small	fair	fair	ACC		fair	fair	dead		
Fall Wine*	good	much	small	good	fair	ACC		little	fair	good	fair	fair

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH APPLES—Continued.

Name.	Record Before 1892.			Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.		Woolly Aphis. 1894.
	Growth.	Woolly Aphis.	Yield.	Growth.	Oyster-Shell Scale.			Growth.	Oyster-Shell Scale.	Growth.	Oyster-Shell Scale.	
Fall Wine*	good	much	small	good	fair	none	.....	good	fair	dead	.....	.....
Disharoon*	strong	none	small	fair	little	BM	.....	fair	little	dead	.....	.....
Disharoon*	strong	none	small	fair	fair	none	.....	good	fair	good	little	little
Early Joe*	.....	.....	.....	good	little	none	.....	none	fair	good	fair	fair
Early Joe*	.....	.....	.....	fair	little	KE	.....	fair	little	dead	.....	.....
Early Harvest	strong	much	small	good	fair	KE	fair	good	fair	good	fair	fair
Golden Sweet	strong	little	good	fair	fair	KE	.....	little	fair	dead	.....	.....
Skinner's Seedling	strong	much	fair	.....	.....	RS	heavy	.....	.....	good	fair	little
Red Astrachan	fair	much	good	.....	.....	RS	good	.....	.....	good	fair	little
Benoni	.....	.....	.....	.....	.....	RS	.....	.....	.....	good	fair	fair
Hoover	.....	.....	.....	.....	.....	RS	few	.....	.....	good	little	fair
Primate	fair	.....	small	.....	.....	RS	fair	.....	.....	dead	.....	.....
Primate	fair	.....	small	.....	.....	RS	fair	.....	.....	good	fair	little
Summer Bellflower*	.....	.....	.....	.....	.....	none	fair	.....	.....	dead	.....	.....
Summer Bellflower*	.....	.....	.....	.....	.....	RS	fair	.....	.....	dead	.....	.....
Summer Rose	small	much	heavy	.....	.....	none	.....	.....	.....	dead	.....	.....
Summer Rose	small	much	heavy	.....	.....	none	.....	.....	.....	dead	.....	.....
McCloud's Family*	.....	.....	.....	.....	.....	none	good	.....	.....	good	fair	little
McCloud's Family*	.....	.....	.....	.....	.....	none	fair	.....	.....	dead	.....	.....
Julian*	.....	.....	.....	.....	.....	none	heavy	.....	.....	good	fair	fair
Julian*	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Summer Queen*	small	much	heavy	good	little	none	fair	fair	little	good	fair	fair
Summer Queen*	small	much	heavy	good	little	ALSS	fair	good	little	dead	.....	.....
Keswick Codlin	fair	bad	heavy	good	fair	ALSS	good	good	fair	good	fair	bad
Keswick Codlin	fair	bad	heavy	good	little	none	good	none	much	dead	.....	.....
Ingram	.....	.....	.....	fair	little	none	.....	good	little	.....	.....	.....
Charlottenthaler †	.....	.....	.....	fair	little	none	.....	fair	little	.....	.....	.....
Summer Hagloe*	fair	much	good	fair	little	none	.....	fair	little	good	fair	bad
Summer Hagloe*	fair	much	good	fair	fair	none	.....	none	fair	good	fair	bad
Sweet June	small	much	fair	fair	little	none	.....	none	fair	good	fair	fair
Clyman's Pippin	.....	.....	.....	fair	little	none	.....	none	fair	good	little	fair
Garretson's Early	small	much	small	good	little	none	fair	fair	little	good	fair	fair
Arkansas Black	.....	.....	.....	.....	.....	none	.....	.....	.....	dead	.....	.....
Seedless	.....	.....	.....	fair	fair	none	.....	fair	fair	dead	.....	.....
Kirkbridge White	small	much	good	fair	fair	none	.....	fair	fair	good	little	fair
Kirkbridge White	small	much	good	small	fair	none	.....	none	fair	good	little	fair

Sops of Wine				small	fair	none		small	fair	dead		
Sops of Wine				fair	fair	ABM		small	little	good	fair	fair
Calville Rouge d'Eté	small		small	fair	fair	ABM		fair	little	good	fair	fair
Calville Rouge d'Eté	small		small	fair	little	ABM		good	little	good	fair	fair

*Indicates selected trees. † Young trees.

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Forelle			good	fair	ABM	good	good	bad	good	little
Vicar of Winkfield	strong	good	good	little	ABM	heavy	small	fair	dead	
Beurré Easter			good	fair	ABM	good	small	fair	fair	little
Pound			good	little	ABM	small	poor	little	dead	
Glout Morceau			good	fair	none	good	poor	fair	good	little
Winter Nelis	fair	small	good	fair	none	poor	poor	fair	fair	little
Doyenne d'Alençon	good	fair	good	fair	none	good	fair	fair	good	little
Bezi Sanspareil*			good	little	none	good	poor	fair	dead	
Bezi Sanspareil*			good	little	none	good	poor	fair	good	little
Passe Colmar*	fair	small	good	little	none		small	little	dead	
Passe Colmar*	fair	small	good	little	none		small	fair	good	little
Pater Noster*			good	little	none	good	small	fair	dead	
Pater Noster*			good	little	none	good	poor	fair	good	little
St. André*			good	little	none	small	fair	fair	good	little
St. André*			good	little	none	small	poor	much	dead	
Marie Louise d'Uccles*	small	good	good	little	none	good	good	little	good	little
Marie Louise d'Uccles*	small	good			IS	good			good	little
Inconnue von Mons*	fair	good	good	little	none	good	fair	fair	good	little
Inconnue von Mons*	fair	good	good	little	IS	good	small	fair	good	little
Fondante de Noël*	fair	good	good	little	none	good	small	much	good	little
Fondante de Noël*	fair	good	good	little	none	good	small	fair	good	little
Epine Dumas*	poor	good	good	fair	none	large	small	fair	good	little
Epine Dumas*	poor	good	good	little	none	small	small	fair	good	little
Belle Williams*	good	small	fair	little	BM	none	good	little	good	little
Belle Williams*	good	small	good	little	none	none	good	fair	good	little
Bergamotte Cadet*	good	fair	good	little	none		fair	little	good	little
Bergamotte Cadet*	good	fair	fair	fair	none		good	little	good	little

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
St. Germain*	good	heavy	good	little	none	small	small	fair	good	little
St. Germain*	good	heavy	good	little	LSS	small	small	fair	good	little
Beurré d'Aremberg*	good	good	fair	little	none	small	small	fair	fair	little
Beurré d'Aremberg*	good	good	fair	fair	LSS	small	fair	fair	dead	.....
Beaupresent d'Artois*	small	good	fair	fair	none	good	fair	fair	good	little
Beaupresent d'Artois*	small	good	fair	little	LSS	good	fair	fair	dead	.....
Beurré Précoce	small	good	fair	little	ALSS	none	small	fair	dead	.....
Beurré Précoce	small	good	good	little	none	good	small	little	fair	little
Calabasse Monstreuse	poor	good	good	little	ALSS	.....	fair	fair	fair	little
Calabasse Monstreuse	poor	good	fair	little	none	.....	poor	fair	dead	.....
Doyenne Sieulle*	fair	good	good	little	ABM	.....	little	fair	good	little
Doyenne Sieulle*	fair	good	good	little	ABM	.....	little	fair	good	little
Chaptal*	.....	.....	good	little	ABM	.....	small	little	fair	little
Chaptal*	.....	.....	fair	little	none	good	poor	fair	dead	.....
Bonne Sophie	poor	fair	.....	.....	none	.....	dead	.....	dead	.....
Bonne Sophie	poor	fair	fair	little	none	.....	poor	little	fair	little
Moyamesing*	strong	small	fair	little	none	good	good	little	good	little
Moyamesing*	strong	small	fair	little	none	good	small	fair	good	little
Idaho†	.....	.....	.....	.....	none	.....	poor	fair	dead	.....
Figue d'Alençon	fair	fair	good	little	none	poor	small	fair	good	little
Washington*	.....	.....	good	little	none	good	.....	.....	good	little
Washington*	.....	.....	.....	.....	none	good	.....	.....	good	little
Star of Bethlehem*	.....	.....	good	little	none	.....	fair	fair	dead	.....
Star of Bethlehem*	.....	.....	good	little	none	.....	small	fair	dead	.....
Prince St. Germain	small	small	good	little	none	good	small	fair	good	little
Prince St. Germain	small	small	good	little	none	none	small	fair	good	little
Chaumontel	.....	.....	good	little	IS	good	fair	fair	good	little
Manning's Elizabeth*	.....	.....	small	little	none	good	fair	little	good	little
Manning's Elizabeth*	.....	.....	fair	little	IS	good	poor	fair	good	little
America*	strong	small	good	fair	none	.....	fair	fair	dead	.....
America*	strong	small	good	little	IS	.....	fair	little	good	little
Josephine de Malines	fair	small	good	little	none	.....	fair	little	good	little
Josephine de Malines	fair	small	good	little	none	.....	good	little	good	little
Augustus Dana*	strong	small	good	little	none	small	good	little	good	little
Augustus Dana*	strong	small	good	little	none	small	small	little	good	little
Beurré Gris d'Hiver Nouveau*	fair	good	.....	.....	BM	good	small	fair	good	little

Beurré Gris d'Hiver Nouveau*	fair	good	fair	little	none	good	fair	little	good	little
Lawrence*	strong	fair	fair	little	BM	heavy	fair	little	good	little
Lawrence*	strong	fair	good	little	none	heavy	good	little	good	little
Doyenne d'Alençon*	good	fair	good	little	LSS	heavy	good	little	good	little
Doyenne d'Alençon*	good	fair	good	little	none	heavy	good	fair	good	little
Bergamotte d'Esperen*	fair	good	good	little	LSS	poor	fair	fair	good	little
Bergamotte d'Esperen*	fair	good	good	little	none	poor	poor	fair	good	little
Columbia*	------	------	fair	little	none	few	small	fair	good	little
Columbia*	------	------	good	little	none	none	poor	fair	good	little
Jaminette	fair	good	good	little	ABM	------	fair	fair	dead	------
Jaminette	fair	good	good	little	none	------	fair	fair	good	little
Rutter*	strong	heavy	good	little	ABM	good	good	little	dead	------
Rutter*	strong	heavy	good	little	none	good	fair	little	good	little
Dr. Reeder*	small	fair	good	little	ABM	good	fair	little	good	little
Dr. Reeder*	small	fair	good	little	ABM	good	small	fair	dead	------
Duchesse de Mouchy†	small	good	good	little	none	------	good	little	dead	------
Duchesse de Mouchy	small	good	good	little	none	good	fair	fair	good	little
André Desportes	fair	fair	good	little	none	good	poor	bad	dead	------
Court Queen	fair	fair	good	little	none	good	poor	fair	good	little
Court Queen	fair	fair	good	little	none	good	small	fair	good	little
Anne Orgereau	fair	fair	good	little	none	good	poor	fair	good	little
Madame Cuissard*	------	------	good	little	none	good	fair	little	good	little
Madame Cuissard*	------	------	good	little	KE	good	fair	fair	dead	------
Mount Vernon*	fair	small	good	little	none	heavy	fair	fair	dead	------
Mount Vernon*	fair	small	fair	little	KE	heavy	poor	fair	good	little
Levard	------	------	fair	little	none	------	small	fair	dead	------
Levard	------	------	good	little	none	good	small	fair	good	little
Napoleon the Third*	strong	good	good	little	none	good	good	little	good	little
Napoleon the Third*	strong	good	good	little	RS	good	small	little	good	little
Beurré Assomption	fair	good	good	little	IS	good	poor	fair	good	little
Beurré Assomption	fair	good	fair	fair	IS	good	poor	fair	dead	------
Louis Vilmorin	small	fair	good	little	IS	none	small	little	good	little
Louis Vilmorin	small	fair	good	little	none	good	poor	fair	dead	------
Eugene Appert*	fair	small	good	fair	none	good	good	little	good	little
Eugene Appert*	fair	small	fair	little	CS	good	good	little	good	little
Brockworth Park*	fair	heavy	good	little	none	heavy	good	little	good	little
Brockworth Park*	fair	heavy	good	little	none	heavy	small	little	good	little
St. Crispin*	------	------	------	------	BM	good	small	fair	good	little
St. Crispin*	------	------	good	little	none	good	small	little	dead	------
Petite Marguerite*	good	good	good	little	none	heavy	good	fair	good	little
Petite Marguerite*	good	good	good	little	none	heavy	fair	little	dead	------
Maréchal Vaillant*	good	small	fair	little	none	good	small	fair	dead	------
Maréchal Vaillant*	good	small	fair	little	LSS	good	small	fair	good	little
Duchesse Précoce	fair	good	fair	fair	LSS	small	small	fair	dead	------
Duchesse Précoce	fair	good	fair	little	none	none	small	fair	fair	little

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Duchesse of Bordeaux*	poor	good	good	little	ALSS	none	small	little	fair	little
Duchesse of Bordeaux*	poor	good	fair	little	ALSS	good	small	fair	good	little
Souvenir du Congrès*	good	fair	fair	little	ALSS	heavy	fair	fair	good	little
Souvenir du Congrès*	good	fair	good	little	none	heavy	small	little	good	little
Duhamel du Monçeau	poor	good	good	little	ABM	heavy	poor	fair	fair	little
Duhamel du Monçeau	poor	good	good	little	ABM	heavy	poor	fair	dead	.....
Pitmaston's Duchesse*	strong	small	good	little	ABM	good	good	fair	good	little
Pitmaston's Duchesse*	strong	small	good	fair	none	good	good	fair	good	little
Madame Treyve	small	good	fair	little	none	.....	poor	fair	dead	.....
Madame Treyve	small	good	fair	fair	none	.....	fair	fair	good	little
Sarah*	.....	.....	fair	little	none	good	good	fair	good	little
Sarah*	.....	.....	fair	fair	none	good	small	fair	good	little
Bonne du Puits Ansault	poor	fair	.....	.....	none	.....	dead	.....	dead	.....
Bonne du Puits Ansault	poor	fair	fair	little	KE	.....	poor	fair	good	little
Madame Loriol de Barney	fair	good	fair	fair	none	good	small	fair	good	little
Madame Loriol de Barney	fair	good	fair	fair	KE	.....	poor	much	dead	.....
Williams' d'Hiver*	.....	.....	good	little	none	light	small	fair	good	little
Williams' d'Hiver*	.....	.....	fair	little	KE	light	.....	.....	dead	.....
Maurice Desportes	small	small	fair	little	RS	none	good	little	good	little
Maurice Desportes	small	small	.....	.....	none	.....	dead	.....	dead	.....
Beurré Clairgeau	fair	fair	fair	little	none	none	small	fair	small	little
Beurré Sterkmans	.....	.....	good	fair	RS	good	fair	fair	good	little
Duchesse	small	small	good	fair	IS	light	poor	much	good	little
Seckel	fair	fair	good	fair	IS	good	fair	fair	good	little
Beurré d'Anjou	fair	fair	good	little	IS	heavy	little	fair	small	little
Andrews	small	good	good	fair	IS	good	small	much	small	little
Ananas d'Eté*	fair	poor	good	little	none	good	good	little	good	little
Ananas d'Eté*	fair	poor	fair	little	CS	good	little	little	good	little
St. Michael Archange*	fair	good	good	little	ACC	good	little	fair	fair	little
St. Michael Archange*	fair	good	good	much	none	good	small	much	fair	little
Rouselet Stuttgart	.....	.....	good	little	none	heavy	small	little	fair	little
Rouselet Stuttgart	.....	.....	good	little	none	heavy	small	little	dead	.....
Jaloise de Fontenay Vendée*	fair	good	good	little	none	good	small	fair	good	little
Jaloise de Fontenay Vendée*	fair	good	good	little	none	good	small	fair	good	little
De Tongres*	good	good	good	fair	none	heavy	good	fair	good	little
De Tongres*	good	good	good	little	none	heavy	small	fair	dead	.....

Henry the Fourth	fair	good	fair	little	none	good	poor	fair	dead	.....
Henry the Fourth	fair	good	.....	.....	none	good	.....	.....	fair	little
Nantals*	fair	good	good	little	ALSS	good	fair	little	good	little
Nantals*	fair	good	good	little	none	none	small	little	dead	.....
Nouveau Poiteau	good	.....	good	little	ALSS	good	fair	little	small	little
Nouveau Poiteau	good	.....	fair	little	ALSS	good	small	little	small	little
Vicar of Winkfield*	strong	good	good	little	none	good	small	fair	fair	little
Vicar of Winkfield*	strong	good	good	little	ALSS	good	fair	little	fair	little
Beurré Goubalt*	heavy	heavy	good	little	none	heavy	small	little	good	little
Beurré Goubalt*	heavy	heavy	fair	fair	none	heavy	good	bad	good	little
Bonne d'Ezée*	fair	heavy	fair	fair	none	good	small	fair	good	little
Bonne d'Ezée*	fair	heavy	good	fair	none	good	fair	fair	good	little
Beurré Golden of Bilboa*	.....	.....	fair	little	none	heavy	good	fair	good	little
Beurré Golden of Bilboa*	.....	.....	good	little	none	heavy	good	fair	good	little
Doyenne Robin	good	good	good	little	none	heavy	fair	little	dead	.....
Doyenne Robin	good	good	good	little	none	heavy	small	little	good	little
Duchesse de Berry d'Eté	fair	small	good	little	KE	good	small	fair	dead	.....
Duchesse de Berry d'Eté	fair	small	good	little	KE	good	little	fair	good	little
Gratiola de Jersey	good	good	fair	little	KE	good	fair	fair	fair	little
Gratiola de Jersey	good	good	fair	little	KE	good	.....	.....	dead	.....
Liberale	fair	fair	.....	little	none	light	fair	little	dead	.....
Liberale	fair	fair	fair	little	RS	light	small	little	good	little
Duchesse d'Orleans*	strong	good	fair	little	none	none	small	fair	dead	.....
Duchesse d'Orleans*	strong	good	good	little	none	good	fair	little	good	little
Flemish Beauty	fair	fair	.....	.....	IS	good	.....	.....	good	little
Admire Joannet*	.....	.....	good	little	none	heavy	good	little	dead	.....
Admire Joannet*	.....	.....	good	little	CS	heavy	good	little	good	little
Baronne de Melo*	fair	good	fair	fair	none	good	good	little	good	little
Baronne de Mello*	fair	good	good	fair	CS	good	good	fair	good	little
Beurré Amande*	fair	good	good	little	none	none	fair	fair	.....	.....
Beurré Amande*	fair	good	fair	little	ACC	none	fair	fair	.....	.....
Kingsessing*	good	small	small	little	none	none	good	little	good	little
Kingsessing*	good	small	good	little	ACC	none	good	little	dead	.....
Ott*	small	fair	good	little	none	good	fair	little	good	little
Ott*	small	fair	good	little	none	good	good	little	good	little
Pratt*	small	small	good	little	none	good	small	fair	good	little
Pratt*	small	small	good	little	SP	good	small	fair	good	little
Stephen's Genessee*	good	fair	small	little	none	.....	small	little	good	little
Stephen's Genessee*	good	fair	fair	bad	SP	.....	fair	bad	good	little
Kirtland*	.....	.....	good	little	none	heavy	small	fair	good	little
Kirtland*	.....	.....	good	little	none	heavy	good	little	good	little
Jones' Seedling	fair	good	.....	.....	none	heavy	.....	.....	small	little
Jones' Seedling	fair	good	good	little	ASP	light	small	fair	small	little
Canandaigua	fair	.....	good	little	ASP	heavy	little	fair	fair	little
Canandaigua	fair	.....	good	little	ASP	heavy	small	fair	fair	little

TABLE GIVING THE RECORD OF THE EXPERIMENTS WITH PEARS—Continued.

Name.	Record Before 1892.		Condition. Spring of 1892.		Treatment. 1892.	Yield. 1892.	Condition. Spring of 1893.		Condition. Spring of 1894.	
	Growth.	Yield.	Growth.	Aspid. Rapax.			Growth.	Aspid. Rapax.	Growth.	Aspid. Rapax.
Fulton	fair	fair	fair	fair	ASP	good	fair	fair	small	little
Fulton	fair	fair	good	little	none	light	small	fair	small	little
Dix	------	------	fair	little	none	none	small	fair	fair	little
Dix	------	------	fair	little	AACC	light	fair	fair	fair	little
Souvenir d'Esperen	------	------	good	little	AACC	light	small	fair	fair	little
Souvenir d'Esperen	------	------	------	------	AACC	none	good	fair	fair	little
Emile de Heyst	fair	good	fair	little	AACC	good	poor	fair	fair	little
Emile de Heyst	fair	good	fair	little	AACC	good	small	fair	dead	------
Dana's Hovey	poor	small	fair	little	KE	poor	small	fair	dead	------
Dana's Hovey	poor	small	small	little	KE	good	small	fair	good	little
Doyenne du Comice	fair	small	good	fair	KE	none	small	fair	fair	little
Doyenne du Comice	fair	small	good	much	KE	good	poor	much	fair	little
Beurré Langlier	strong	fair	good	little	RS	good	fair	fair	good	little
Beurré Langlier	strong	fair	small	little	RS	light	small	fair	dead	------
Oswego Buerré*	good	fair	fair	little	none	none	small	fair	good	little
Oswego Buerré*	good	fair	good	little	RS	light	poor	fair	good	little
Doyenne White	fair	good	fair	fair	IS	heavy	good	fair	good	little
Doyenne White	fair	good	fair	little	CS	heavy	small	fair	dead	------
Conseiller de la Cour*	heavy	good	good	little	none	heavy	fair	fair	good	little
Conseiller de la Cour*	heavy	good	little	fair	CS	heavy	small	fair	good	little
Urbaniste*	good	fair	good	little	none	none	fair	fair	good	little
Urbaniste*	good	fair	fair	fair	ACC	light	small	fair	good	little
Paradise d'Automne*	good	good	good	little	none	none	fair	fair	good	little
Paradise d'Automne*	good	good	good	fair	ACC	good	good	fair	good	little
Beurré Hardy*	good	fair	good	fair	none	light	small	fair	fair	little
Beurré Hardy*	good	fair	good	little	none	none	small	little	fair	little
Sheldon	fair	good	good	little	none	none	dead	------	------	------
Sheldon	fair	good	good	little	SP	light	good	little	good	little
Howell*	good	good	good	fair	none	good	small	little	dead	------
Howell*	good	good	good	little	SP	good	good	fair	good	little
Napoleon*	------	------	good	fair	none	light	fair	fair	dead	little
Napoleon*	------	------	good	little	none	light	small	fair	good	little
Beurré Bosc	strong	small	good	little	ASP	good	fair	little	good	little
Swan's Orange*	fair	good	------	------	none	good	------	------	fair	little
Swan's Orange*	fair	good	------	------	ASP	good	------	------	fair	little
Beurré Diel*	fair	fair	------	------	none	good	------	------	fair	little

Beurré Diel*	fair	fair	------	------	ASP	light	------	------	fair	little
Louis Bonne de Jersey*	fair	good	good	fair	none	good	small	fair	good	little
Louis Bonne de Jersey*	fair	good	------	------	none	good	small	fair	good	little
Paul Ambre*	------	------	good	little	none	none	small	little	small	little
Paul Ambre*	------	------	good	fair	AACC	light	small	little	small	little
Buffum*	fair	good	fair	fair	none	light	small	fair	small	fair
Buffum*	fair	good	fair	little	AACC	good	poor	bad	small	fair
Beurré Superfin	fair	small	good	little	AACC	light	fair	fair	fair	little
Beurré Superfin	fair	small	fair	little	KE	none	small	fair	fair	little
Doyenne Boussock*	strong	good	good	little	KE	heavy	small	fair	good	little
Doyenne Boussock*	strong	good	good	little	KE	heavy	fair	fair	good	little
Gray Doyenne	------	------	fair	little	RS	none	small	fair	dead	------
Gray Doyenne	------	------	fair	little	RS	none	small	little	small	little
Beurré de Waterloo*	fair	fair	good	little	none	good	fair	little	fair	little
Beurré de Waterloo*	fair	fair	good	little	RS	good	fair	fair	fair	little
Madeleine	strong	small	good	little	CS	good	fair	fair	good	little
Beurré Giffard	good	fair	good	little	CS	good	good	little	good	little
Dearborn's Seedling	strong	fair	good	little	CS	good	fair	little	good	little
Osband's Summer	------	------	good	little	none	good	fair	fair	good	little
Osband's Summer*	------	------	good	little	ACC	good	fair	fair	good	little
Belle Lucrative*	strong	good	good	little	none	heavy	fair	fair	good	little
Belle Lucrative*	strong	good	good	little	ACC	heavy	small	fair	good	little
Rostiezer*	good	small	good	little	none	good	poor	little	good	little
Rostiezer*	good	small	good	little	SP	good	good	little	good	little
Bartlett*	good	fair	fair	little	none	good	fair	little	good	little
Bartlett*	good	fair	good	little	none	good	fair	little	good	little
Tyson*	------	------	good	little	none	good	good	little	good	little
Tyson*	------	------	good	little	SP	------	good	little	good	little
Brandywine	good	good	good	little	none	good	good	little	good	little
Doyenne d'Eté*	small	fair	------	------	none	good	------	------	good	little
Doyenne d'Eté*	small	fair	------	------	ASP	none	------	------	dead	------
Clapp's Favorite*	good	good	------	------	none	good	------	------	good	little
Clapp's Favorite*	good	good	------	------	ASP	good	------	------	good	little
Edmonds*	strong	heavy	------	------	none	none	------	------	dead	------
Edmonds*	strong	heavy	------	------	ASP	none	------	------	dead	------
Bloodgood*	good	good	good	little	none	good	small	fair	small	little
Bloodgood*	good	good	good	little	none	good	small	fair	dead	------
P. Barry	------	------	fair	little	KE	------	------	------	small	little
Le Conte	------	------	------	------	KE	------	------	------	good	little
Keiffer	------	------	------	------	RS	------	------	------	good	little
Keiffer	------	------	------	------	RS	------	------	------	good	little

*Indicates selected trees. †Small trees.

The treatments were made in the spring of 1892, just before the buds began to open, as indicated on the plot. In the spring of 1893 all the orchard was treated with resin soap, and this spring no treatment at all was made.

No results from the wash could be noted in the trees in the summer of 1892. Not that there was no difference between the various trees, but attempts to pick out trees that were washed and those not washed were as often wrong as right. It was hoped, however, that by taking a number of items and large averages some results could be obtained, so the above tables were prepared. The record before 1892 and the yield of 1892 are compiled from the notes of the Station foreman; the other columns are from my own observations.

The season of 1891, as shown by the growth observed in the spring of 1892, was good, but the year following the application was by no means as satisfactory, though the yield was very fair. Last year was very good, and this year promises to be also very good. The variation in the abundance of scale insects seems to follow the growth in inverse order, and this, broadly speaking, seems to be true of insect attack in general.

The pears were all more or less affected with the greedy scale, *Aspidiotus rapax*, which is very abundant on a great variety of trees on the University grounds, and all over town. They occur in small numbers on all kinds of fruit trees, including the olive and citrus trees, as well as the deciduous fruit, but are very abundant only on the pears, and one or two varieties of apples and cherries. On the California bay laurels along the creek, quite near the orchard, this scale was very abundant about the time these experiments were begun, but have now almost all disappeared, apparently the result of a disease. In the Economic Garden, below the orchard, the scale was very abundant on quite a number of exotic trees, and they have similarly decreased, but accompanied in this instance by a great increase in numbers of the twice-stabbed ladybird. In the town a decrease of the scale, though not quite so well marked, clearly results from the work of the English sparrow. The ladybirds and sparrows have not been unusually abundant in the orchard, and the disease seems to have been the chief natural check.

The oyster-shell scale was very abundant on a number of the apples, and present in some numbers on all, and on a very few pears, but apparently on no other trees. The same or a similar disease to that attacking the *A. rapax* was noticed, but no other natural enemies.

The only other insects very abundant in the orchard were the woolly aphis and the codlin moth. These have been treated of to some extent in the last two reports. Further data is given above in regard to the former.

In the tables above, the terms small, fair, and good are used as being more intelligible than figures, but for comparison it becomes necessary to use numbers, so that they may be added and the averages obtained. In the tables below the following values are given to the words used in the first tables:

1 = none, poor, few. 3 = fair.
2 = small, little, light. 4 = large, much, good.
5 = strong, heavy, bad.

Table showing the Yield of the Apples and Pears.

Treatment.	Apples.				Pears.			
	Before 1892.		Summer of 1892.		Before 1892.		Summer of 1892.	
	No. of Trees.	Yield.	No. of Trees.	Yield.	No. of Trees.	Yield.	No. of Trees.	Yield.
Resin soap	11	2.6	8	3.1	7	3.0	10	2.5
do arseniated	1	2.0	2	3.5				
Ammoniacal copper carbonate	8	3.0	2	3.5	6	3.5	7	3.0
do arseniated	3	3.7	2	3.5	4	3.5	8	2.6
Sulphid of potash					5	3.0	4	3.5
do arseniated					8	3.5	10	3.2
Copper sulphate					8	3.0	9	4.3
Kerosene emulsion	5	3.0	6	3.5	14	2.8	14	3.4
Bordeaux mixture	2	2.0			3	3.0	4	3.5
do arseniated	5	2.2	3	3.7	10	3.7	10	4.1
Lime, salt, and sulphur	14	2.8	9	3.5	7	3.7	7	2.9
do arseniated	4	4.5	4	4.0	7	3.9	8	3.4
Iron sulphate					12	3.3	12	4.0
Untreated	50	3.1	37	3.5	112	3.4	126	3.5

Table showing the Growth of the Apple Trees.

Treatment.	Before 1892.		Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.
Resin soap	11	3.2	2	4.0	3	3.3	13	4.0
do arseniated	1	3.0	4	4.0	4	4.0	2	4.0
Ammoniacal copper carbonate	8	2.9	12	3.8	12	3.8	6	4.0
do arseniated	3	4.3	5	4.0	6	3.5	3	4.0
Kerosene emulsion	5	4.3	18	3.4	21	3.2	12	4.0
Bordeaux mixture	2	5.0	5	3.4	5	3.4	1	4.0
do arseniated	5	2.2	8	3.6	8	3.6	6	4.0
Lime, salt, and sulphur	14	3.6	19	3.8	22	3.6	18	4.0
do arseniated	4	2.3	4	3.8	4	3.8	3	4.0
Untreated	50	3.3	67	3.6	74	3.3	51	4.0

Table showing the Growth of the Pear Trees.

Treatment.	Before 1892.		Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.	No. of Trees.	Growth.
Resin soap	7	2.9	10	3.4	10	2.4	10	3.7
Ammoniacal copper carbonate	6	3.8	7	3.7	7	2.9	5	3.8
do arseniated	4	3.0	7	3.4	8	2.3	7	2.7
Sulphid of potash	5	3.4	6	3.8	6	3.5	6	4.0
do arseniated	10	3.4	5	3.8	5	2.4	8	3.0
Copper sulphate	8	3.9	9	3.4	9	3.1	8	4.0
Kerosene emulsion	14	3.0	17	3.4	14	1.9	12	3.5
Bordeaux mixture	3	4.0	2	3.0	4	2.8	4	4.0
do arseniated	10	3.0	14	4.0	14	2.4	8	3.6
Lime, salt, and sulphur	7	3.5	7	3.4	7	2.7	4	4.0
do arseniated	9	2.8	9	3.6	9	2.6	8	3.1
Iron sulphate	12	2.6	12	3.8	12	2.1	13	3.8
Untreated	112	3.3	134	3.7	134	2.5	112	3.8

Table showing the Abundance of the Oyster-shell Scale on the Apples.

Treatment.	Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Abundance.	No. of Trees.	Abundance.	No. of Trees.	Abundance.
Resin soap	2	2.0	3	2.7	13	2.7
do arseniated	4	2.5	4	2.8	2	3.0
Ammoniacal copper carbonate	12	2.8	12	3.0	6	3.0
do arseniated	5	2.6	6	2.5	3	2.0
Kerosene emulsion	18	2.7	21	2.9	12	2.9
Bordeaux mixture	5	2.2	5	2.4	1	2.0
do arseniated	8	2.5	8	2.1	6	2.7
Lime, salt, and sulphur	19	2.6	22	2.5	18	2.3
do arseniated	4	2.2	4	2.5	3	2.7
Untreated	67	2.5	74	2.8	51	2.6

Table showing the Abundance of the Greedy Scale on the Pears.

Treatment.	Spring of 1892.		Spring of 1893.		Spring of 1894.	
	No. of Trees.	Abundance.	No. of Trees.	Abundance.	No. of Trees.	Abundance.
Resin soap	10	2.9	10	2.5	10	2.0
Ammoniacal copper carbonate	7	2.3	7	2.9	5	2.0
do arseniated	7	2.1	8	3.1	7	2.1
Sulphid of potash	6	2.5	6	2.8	6	2.0
do arseniated	5	2.2	5	2.8	8	2.0
Copper sulphate	9	2.2	9	2.4	8	2.0
Kerosene emulsion	17	2.2	14	3.1	12	2.0
Bordeaux mixture	2	2.0	4	2.5	4	2.0
do arseniated	14	2.4	14	2.9	8	2.0
Lime, salt, and sulphur	7	2.3	7	2.9	4	2.0
do arseniated	9	2.0	9	2.4	8	2.0
Iron sulphate	12	2.4	12	3.0	13	2.0
Untreated	134	2.1	134	2.7	122	1.8

Table showing the Abundance of the Woolly Aphis on the Apples.

Treatment.	Before 1892.		Summer of 1894.	
	Number of Trees.	Abundance.	Number of Trees.	Abundance.
Resin soap	6	4.2	13	2.8
do arseniated	1	5.0	2	3.0
Ammoniacal copper carbonate	6	2.7	6	2.7
do arseniated	3	2.0	3	2.0
Kerosene emulsion	5	3.0	12	2.9
Bordeaux mixture	2	2.5	1	3.0
do arseniated	3	3.7	6	2.5
Lime, salt, and sulphur	10	3.0	18	2.3
do arseniated	4	4.0	3	3.3
Untreated	43	3.6	51	2.8

In preparing the above tables the selected trees only were used, until it was seen that it made no material difference in the figures when all the trees were used, to give greater value to the averages. In every case the number of trees included in an average is given.

Yield after Treatment.—The yield gives the most tangible record of the results of the treatment. The season following the application

shows a larger yield than the earlier record, and this increase is somewhat greater in the treated trees than in those untreated, but the difference is too slight to have any significance. Only with iron sulphate and copper sulphate is there a decided increase over the untreated trees. The results are sufficiently distinct with these, however, and probably represent the amount of reduction of the pear scab, which is quite prevalent all over the orchard. It is interesting to note that all of the other fungicidal washes excepting Bordeaux mixture showed, if anything, the opposite results on the pears, the two most used in this State: sulphid of potash, and lime, salt, and sulphur, making no better showing than the weak ammoniacal copper carbonate, which has never been recommended except for summer use.

Growth after Treatment.—The character of the growth is a very good index of the condition of a tree, and should therefore permit one to judge very accurately of the effect of a treatment. It will be noticed that the growth recorded in the spring of 1893, which represents that made the preceding summer, when the various washes would have their effects, if at all, shows in no case an increased growth over the preceding year, whereas the following season presents no case of decrease. This might suggest that the resin soap used in 1893 was very beneficial, were it not a fact that the trees treated with this wash in 1892 show about the greatest decrease in growth of all. The great variation in the first column is explainable on the ground that it is estimated upon a somewhat different basis from the other columns, and by a different person, and is therefore not so closely comparable. The apples treated with resin soap and arseniated ammoniacal copper carbonate decreased decidedly more in their yield than the others, and with Bordeaux mixture, both simple and arseniated ammoniacal copper carbonate and the arseniated resin soap and arseniated lime, salt, and sulphur, the growth was the same as the year before. A careful study of the whole table leaves one in doubt as to the significance of these facts. In the pear orchard the trees treated with sulphid of potash, Bordeaux mixture, and copper sulphate show decidedly less decrease in growth as compared with the others, but the two former lots are not large enough in number of trees to give much significance to this fact, especially since the arseniated treatments in neither of these cases show the same results. On the whole, it is evident that judging from the growth alone, the effects of the treatments were about nothing.

Scale Insects.—The destruction of scale insects is generally looked upon as the chief object of washing trees. The most evident fact brought out by the tables of scale-abundance is that neither for the oyster-shell scale nor for *Aspidiotus rapax* was any of the washes tried even fairly successful in killing the scale; and this result was not at all due to any lack of thoroughness of treatment. The simple fact is that none of these washes, as ordinarily applied, are able, under these conditions, to destroy these scales. In the apple orchard the trees treated with arseniated ammoniacal copper carbonate, lime, salt, and sulphur, and arseniated Bordeaux mixture showed a decrease in the abundance of the scale, and all the others an increase; while on the pears with the *Aspidiotus rapax* the resin soap was the only wash capable of producing any appreciable effect.

The woolly-aphis table is given to complete the *résumé* of the experi-

ments, though the records were not taken near enough to the treatments to give much weight to the results.

A very slight abatement of pear scab where strong fungicides were used, and a still more slight decrease in the abundance of the scales in some cases, can be looked upon as the total appreciable results of the treatments. What the decrease in the abundance of the scales amounted to it is difficult to say, as neither the yield nor the character of the growth of the trees showed anything in these cases. There are no data available as yet showing even approximately the average amount of injury due to scale insects. A comparison of the relative abundance of the scales with the growth of the trees the following season should give a fair idea of the amount of this injury.

Relation of Scale to Tree Growth.—The following table compares the scale conditions in the springs of 1892 and 1893 with the growth observed in the springs of 1893 and 1894, respectively, of all the trees in which we have data:

Table showing the Relation of Scale Insects and Tree Growth.

Abundance of Scales.	Growth.					No. Dead.	Per cent Dead.
	Poor.	Small.	Fair.	Good.	Aver-age.		
Pears.							
Little	26	85	58	87	2.8	13	5.0
Fair	5	22	31	101	3.4	27	14.5
Much	1	2	2	2	2.7	2	22.2
Bad	.....	1	1	3	3.4	1	16.7
Apples.							
Little	7	2	27	74	3.5	21	15.9
Fair	4	5	16	90	3.7	31	20.8
Much	.....	1	2	6	3.6	3	25.0
Bad	.....	.....	.....	3	4.0	1	25.0

The above table gives the entirely unlooked-for result that on the more infested trees the growth is decidedly the best. The death-rate, however, is distinctly larger on the worst infested trees. These facts indicate that the scales exert no appreciable effect on healthy trees, but that on trees that are in a bad condition they do become very serious matters.

Practical Suggestions.—Two items, therefore, must be considered in the logical treatment of trees for scales: the maintenance of a vigorous condition of the tree, and the destruction of the scale; and if either of these measures is successful all injury from this source will be prevented. It is entirely possible for a tree to be in a satisfactorily healthy condition and still badly infested with scale insects. If one of these two items fails, especial attention must be given to the other. Thus in a dry season it becomes impossible to preserve the healthy condition of the tree, and then the destruction of the scale becomes an important matter. On the other hand, if a good season is at hand, of which we are often able to judge with a good degree of certainty, the spraying may be neglected with impunity and an opportunity given for the multiplication of the natural enemies of the scale, and these may be able to keep the scale in check for a number of years to come. This suggestion does not,

of course, apply to those regions where it has become the policy to eradicate entirely certain scales.

The fact that neglected orchards though left to themselves become spontaneously clean after having been overrun by scales is proverbial, and has been observed by almost every one. This should not be looked upon as proving the general uselessness of washes, but it does speak eloquently of the folly of spraying by rote.

Misconceptions as to the action of insecticides often occur under such circumstances, and the wonderful testimonials for harmless and useless remedies by good, honest men are easily understood.

The importance of spraying, however, should not be underestimated. It is often the line dividing failure and success. What these experiments have proven, and what should be impressed, is that the common method of spraying once each winter is, under some circumstances, a valueless and wasteful procedure.

REMEDIES FOR PLANT DISEASES.

The following list of remedies for plant diseases was sent out as a special bulletin to meet the constant demand for information on the subject:

For POWDERY MILDEWS use *sulphur*, dusting it on the plants.

For FUNGI in general use *Bordeaux mixture*, made as follows: For every 10 gallons take 1 pound of lime and 1 pound of bluestone. Dissolve these separately in hot water and mix when cool, adding the rest of the water. Spray on the plants. Or spray with *ammoniacal copper carbonate solution*, made as follows: Dissolve 1 ounce of copper carbonate in 6 ounces of ammonia and add 10 gallons of water.

For FUNGI and SCALE INSECTS use *lime, salt, and sulphur mixture*, a **winter** wash composed of lime 8 pounds, salt 3 pounds, and sulphur 4 pounds, for each 12 gallons of water. Mix one fourth of the water, one fourth of the lime, and all the sulphur, and boil for one and a half hours; put the salt with the rest of the lime and slake with hot water; add to the above and boil half an hour longer; add the remainder of the water and apply as a spray.

For SCALE INSECTS use *resin soap*, as follows: For 100 gallons for **summer** use take resin 18 pounds, caustic soda (98 per cent) 3½ pounds, and fish oil 2½ pints; for **winter** use, resin 30 pounds, caustic soda 6¼ pounds, and fish oil 4½ pints. The material is put in a kettle and covered with four or five inches of water. The lid is put on and the mixture boiled two hours or more, and then the rest of the water is added, a little at a time. Spray on the plants. Or use the *gas treatment:* Cover the plant with an oiled tent, and for each 100 cubic feet of contents place in a bowl beneath the tent ⅔ ounce of water, ⅓ ounce of sulphuric acid (oil of vitriol), and ¼ ounce of potassium cyanide (58 per cent), being careful not to inhale the poisonous gas nor to allow it to escape from the tent for half an hour. The leaves may be injured if used during the middle of the day.

For INSECTS in general use *kerosene emulsion*, as follows: Make a soap solution of half a pound of soap to a gallon of water. Heat it to boiling and add two gallons of kerosene. Pump it through the spray pump, with good pressure, for five to ten minutes. For use add ten times as much water as you have of emulsion. Apply as a spray. Sour milk may be used instead of the soap solution. The emulsion is made more effective by the addition of a very small amount of arsenic to the soap solution, or of buhach to the kerosene.

For FRUIT OR LEAF-EATING INSECTS use *Paris green* or *London purple* as a powder at the rate of 1 to 5 pounds to the acre, distributed by walking or riding over the field, carrying a pole, at both ends of which are hung muslin bags containing the poison. As a spray use 1 pound to 200 gallons of water. In spraying these arsenites the nozzle should be held at some distance from the plant and *no more should be applied after the leaves begin to drip.* Do not use these on crops where the poison would be injurious to health.

APPENDICES.

I. The Experiment Station Exhibit at the World's Fair in Chicago, and at the Midwinter Fair in San Francisco.

II. Fruit Tree Catalogue of varieties in the orchards of the Experiment Stations.

III. The Library and Reading-Room of the Station.

IV. Financial Statements.

THE EXPERIMENT STATION EXHIBIT

AT THE

WORLD'S FAIR IN CHICAGO, AND MIDWINTER FAIR IN SAN FRANCISCO.

By R. H. Loughridge.

At the meeting of the Association of Agricultural Colleges and Experiment Stations held in 1891, a committee was appointed to formulate plans for and to take charge of an exhibit at the Columbian World's Fair in Chicago, which would in the best manner represent the work being carried on by the Agricultural Colleges and Stations throughout the United States. The committee divided the proposed exhibit into the appropriate groups, and special agents were placed in charge of the preparation of each.

Each College and Experiment Station was then called upon for something of its material for these divisions, so as to make the whole as national in character as possible. For the division of soils, Prof. E. W. Hilgard, Director of the University of California Stations, was placed in charge; the coöperation of each Station in the United States was asked to make the representation of the characteristic soils of each State as complete as possible.

As the space allotted to the soil-exhibit was very limited, it was found that only from ten to eighteen soils could be sent from each State, when taken in the manner desired. Each sample was to represent not the surface soil only, but a section to a depth of three feet, and to be in the form of a solid column of undisturbed earth, four inches wide and three inches thick. In this form could be seen all of the varying features to a depth of three feet, or that reached by the roots of most crops. These columns were to be placed in boxes with glass fronts, and labels giving locality, natural vegetation, and the crops to which best adapted. It was hoped that chemical and mechanical analyses would accompany each sample, but most of the stations were not able to have these made.

After these preliminaries were arranged, Professor Hilgard was granted a year's leave of absence from the University, and the writer was appointed special agent in his place, to complete arrangements for the exhibit. Many of the stations were for various reasons, chiefly financial, not able to send soil samples, so that, as finally presented, there were about 300 soils prepared and exhibited, from the following States:

Alabama	10	New York	20
California	16	North Carolina	15
Colorado	6	Oklahoma	5
Connecticut	15	Ohio	3
Florida	13	Oregon	11
Illinois	6	Rhode Island	8
Kentucky	16	Tennessee	15
Kansas	9	Texas	12
Massachusetts	13	Utah	4
Mississippi	18	Washington	16
Nebraska	8	Wyoming	7
Nevada	13		
New Mexico	10	Total	285

THE CALIFORNIA EXHIBIT AT CHICAGO.

SOILS.

California, as one of the largest States, and having more varied climatic and agricultural regions, was entitled to sixteen samples of soils as representing the more important regions. The localities from which the soils were to be taken were chosen so as to be fairly characteristic of each region; and the duty of collecting the samples was placed in the hands of C. H. Shinn, the Inspector of Stations. The following general agricultural regions were selected: The Bay region; Santa Clara Valley; San Miguel Valley; Napa Valley; Sonoma Valley; Redwoods region; San Joaquin Valley; Sacramento Valley; Lower Sierra Foothills; San Bernardino Valley; ten regions in all, and from some of them two and even three samples, as representing that many varieties of soil, were chosen.

Analyses of each sample, both chemical and mechanical, were made, where not already on hand; the sediments obtained in the mechanical analysis placed in vials to accompany the respective soils; proper labels prepared showing locality where each soil was taken, the natural vegetation, the soil characteristics, and the crops to which best adapted.

The following comprise the soils and localities from which taken, and also the name of the collector. The analyses will be found either in previous reports of this Station or elsewhere in the present one:

Coast Region Soils.

North of the Bay Region: *Redwood Soil*, from the heavy forests on the land of Col. J. B. Armstrong near Guerneville, Sonoma County, and collected under his direction. It is coextensive with the redwood belt as shown on the map in Vol. 9, Report Tenth Census of the United States. The mechanical and chemical analyses of this soil are found elsewhere in this report. The land is but little cultivated because of the heavy cost of clearing. It is, however, a first-class soil, and highly productive when planted to grapes and deciduous fruits.

Sonoma Valley Vineyard Soil; from J. H. Drummond's vineyard, near Glen Ellen, Sonoma County. This is a brownish, rather clayey loam from the lower vineyard; without perceptible change of nature or tint to three feet, the substratum below that depth gradually becoming more reddish and lighter in texture beyond the depth of four feet. It has a natural timber growth of scattered white oaks. It is a fairly productive soil and first class for wine grapes and fruits, especially almonds and deciduous fruits. The sample was taken by C. H. Shinn; it represents a large area of hill and slope lands in Sonoma and Napa Counties. The analysis and description of similar soils are given in the Reports for 1883 and 1887.

Napa Valley Vineyard Soil, from the place of H. W. Crabb, 3 miles east of Rutherford, Napa County. The soil is a reddish-gray loam, containing considerable angular gravel, but silty rather than sandy; when dry the lumps crush readily between the fingers. The land originally had a natural growth of white oaks. The sample was taken by C. H. Shinn. The mechanical and chemical analyses of this soil appear elsewhere in this report. The sample represents fairly the majority of the fruit lands of the upper Napa Valley.

THE BAY REGION: *Black Adobe Soil*, from the grounds of the University of California, Berkeley, Alameda County. A grayish-black clay soil, resembling the prairie soils of Illinois or Mississippi; evidently an ancient swamp deposit. It contains chiefly angular gravel of various rocks, mostly shales, that form the Coast Range at this point. When dry, the soil forms hard lumps, which do not yield to the fingers; on wetting it becomes very tenacious; in the dry season, when untilled, it opens into wide and deep suncracks. The natural growth is live oak, laurel, buckeye, buckthorn, etc. This is a first-class grain land, the climate not being adapted to commercial fruit culture. No irrigation is needed. The mechanical and chemical analyses are given elsewhere (No. 1679) in this report. This soil represents a highly productive belt of alluvial lands surrounding the bays of San Francisco and San Pablo.

SOUTH OF THE BAY REGION: *Santa Clara Valley Soil*, from the land of the Saratoga Prune Company on western valley slope, 4 miles west from San José, Santa Clara County. This is a drab-tinted loam, largely intermixed with gravel and rock fragments, which increase downwards; evidently washed from the Coast Range to westward. The tint becomes more yellowish toward three feet depth. The entire soil stratum is from 12 to 20 feet thick, and roots are naturally underdrained; and it tills easily, shortly after rains. The natural growth is chiefly herbaceous, with scattered white oaks. It is a first-class soil, yielding without irrigation, wine grapes, prunes, apricots, pears, cherries, figs, and small fruits. The sample was taken by C. H. Shinn. The mechanical and chemical analyses of a similar soil from Cupertino, No. 986, will be found in the Report for 1886. It represents the western slope of the Santa Clara Valley, occupied mainly by prune orchards and vineyards.

Mesa Soil from the Southern Coast Range Station, near Paso Robles, San Luis Obispo County. Yellowish drab in color, very loose and sandy, the sand consisting mostly of granite debris. The natural growth is Douglass' and white oak, with "openings" having a sparse growth of bunch grass and herbs. It represents the Estrella Plains of the upper Salinas River. The mechanical analysis of this soil, No. 1147, will be found in this report; the chemical analysis appeared in the Report for 1890.

Sediment Soil of the Valley of Santa Clara River, from the orchard of N. W. Blanchard, near Santa Paula, Ventura County. This is a silty soil, light in color, and easily tilled; of first quality, and produces citrus fruits, apricots, beans, and corn without irrigation. The sample was collected by C. H. Shinn. An analysis of a similar soil (No. 168) will be found in the Report for 1882. It represents the old alluvium or bench lands of that valley and of the Saticoy region.

Lower Sierra Foothills Region.

Granite Soil, from the Experiment Station near Jackson, Amador County. Its natural growth is pine and chaparral. It is much inferior to the red foothill soil, but produces deciduous fruits. It is much benefited by irrigation. Its chemical and mechanical analyses appear respectively in the Reports for 1890 and 1891. The sample was taken by Geo. Hansen, foreman of Station, and C. H. Shinn. It represents the lands

of the granite areas which are interspersed among the "bedrock slates" of the western slope of the Sierra.

Red Foothill Soil (derived from the slate bedrock), from the Experiment Station near Jackson, Amador County. This is of first quality, having a natural growth of mountain oaks, and pines, buckeye, buckthorn, manzanita, madrone, chaparral, poison sumac, etc. It is much benefited by irrigation, and produces deciduous and citrus fruits, figs, and grapes. Its chemical and mechanical analyses appear respectively in the Reports for 1890 and 1891. The sample was collected by C. H. Shinn and Geo. Hansen. It represents the soils derived from the "bedrock slates" in which the placer mining of early times for gold was done.

Great Valley Region.

SACRAMENTO VALLEY: *Old Alluvium* or *"Middle-land" Soil*, from Putah Creek, near Dixon, Solano County. A mouse-colored clay loam, becoming quite plastic but not adhesive on wetting and kneading. Thickness from 12 to 20 feet to water. The natural growth is chiefly herbaceous, with scattered white oaks. The soil is first class in quality, producing table and wine grapes, apricots, prunes, pears, figs, and almonds. The sample was collected by C. H. Shinn. A chemical analysis of land of this character, No. 110, will be found in the Report for 1882. The mechanical analysis appears elsewhere in this report. It represents the alluvium of the western side of the Sacramento Valley.

Sacramento Valley Soil, from the place of R. C. Kells, 3 miles west of Yuba City, Sutter County. A loam of light-brownish tint, growing paler downward, varying in thickness from 8 to 12 feet, and then usually underlaid by gravel, therefore well drained. It is usually above overflow—characteristic of the Sacramento Valley between Feather River and the base of the foothills. The natural growth is chiefly herbaceous, with scattered white oaks. This is a first-class soil, producing citrus fruits, pears, prunes, apricots, and almonds, and mostly cultivated without irrigation. The sample was collected by Messrs. R. C. Kells and C. H. Shinn. The analysis, both mechanical and chemical, of the soil, No. 1645, appears elsewhere in this report.

SAN JOAQUIN VALLEY: *Reddish Sandy Soil*, from the ranch of C. C. Butler, near Fresno, Fresno County. A reddish-gray sandy loam, easily tilled at all times, varying somewhat in its degree of fineness and cohesiveness; easily irrigated and holding water well. It is from 8 to 25 feet in thickness and with little change; it represents the ancient alluvium of the upper San Joaquin River. Its natural growth is herbaceous. It is a first-class soil, requiring irrigation, and producing wine and raisin grapes, apricots, prunes, pears, alfalfa, figs, and almonds. A chemical analysis of this kind of land appears in the Report for 1890, while the mechanical analysis is presented in this. The sample was taken by C. H. Shinn.

Sandy Plains Soil, from the Experiment Station near Tulare. A yellowish-drab or fawn-colored, very sandy loam, easily tilled at all times; but little change to 12 feet. It has a natural growth of large white oaks, and is of good quality, but inferior to the "black lands" of the region. It is profusely productive under irrigation, and is well adapted to grain,

alfalfa, deciduous fruits, and grapes. The sample was collected by Julius Forrer, the foreman of the Station. Its chemical analysis is given in the Report for 1889, and the mechanical analysis in that of 1891–92. It represents the ancient alluvium of the Kaweah River and its delta.

Black Lands Soil, or old swampy alluvium of Tulare Lake, Tulare County. A friable loam of dark mouse color, almost black when wet. It represents the ancient swamp deposits of the Tulare Lake border, and of its eastern affluents. Its depth is 8 to 12 feet, with but little change. It has no natural timber growth, and is of first quality, requiring but little irrigation, and producing grain, apricots, prunes, pears, etc. A chemical analysis of this variety of land, No. 1167, appears in the Report for 1882, and the mechanical analysis in that of 1891. The sample of soil was taken by Julius Forrer, foreman of the Station.

Southern California Region.

Reddish Bench, or Mesa Soil, from the site of the first orange grove in the town of Riverside. The natural growth is herbaceous only. This is the typical land of orange orchards; is first class in character, requires irrigation, and produces citrus fruits, grapes, and apricots. Its mechanical analysis appears elsewhere in this report. The sample was taken by Mr. J. E. Cutter.

Bench, or Mesa Soil, from the Experiment Station tract on Chino Ranch, San Bernardino County. A sandy loam of light cinnamon tint; an ancient valley alluvium. It is a first-class soil, with an herbaceous growth only. It requires irrigation, and produces citrus fruits, apricots, prunes, pears, and figs. Its chemical analysis appears in the Report for 1890; the mechanical analysis is given elsewhere in the present report. The sample was collected by C. H. Shinn.

AGRICULTURAL MAP OF CALIFORNIA.

For the past fifteen years this office has been accumulating data for the construction of a map which shall show as accurately as possible the close outlines of the many soil regions of the State. The information is not yet at all complete, and there are still large areas in which the lines marking distinct agricultural regions have not been closely defined. This is specially the case in the sparsely populated portions of the State, comprising the mountains and interior valleys. But still enough data have been collected to enable us to construct a map that gives very fairly the general soil regions, and some of the minor ones. Much assistance was rendered by the United States Topographical Corps, under Professor W. D. Johnson, in supplying contour outlines of mountain ranges and their valleys; also by several citizens of the State. Copies of a large base map of the State, 4 by 5 feet, were obtained through the courtesy of the State Mining Bureau, and upon this the regions selected for representation were outlined and defined by characteristic colors. The following regions were thus presented:

Great valley.
River and lake lands.
Tules.
Black adobe.
Black lands of Tulare.
Bedrock land of Sacramento Valley.
Red lands of Fresno and Tulare.

Lower foothills region; from valley to 2,500 feet elevation.
Upper foothills; 2,500 to 3,500 feet elevation.
Granite lands.
Interior high valley and mesa lands.
Cultivable portion of Mojave Plateau. (Known or presumed to be cultivable, having a growth of yucca trees; irrigable from wells on west side of railroad; in eastern portion irrigable from Mojave River.)
Cultivable Coast Range. (Largely Tertiary and partly Cretaceous; mostly forming rounded ranges with sufficient soil for cultivation.)
Redwoods region.
High Coast Range.
High Sierras.
Lava beds.
Desert.
} Uncultivable land.

The whole map was then mounted and varnished and forwarded to the World's Fair, to be placed in the soil alcove. It was one of but few State soil maps there exhibited.

EXHIBIT OF MINERALS AND ROCKS TO ILLUSTRATE SOIL-FORMATION.

At the special request of Major Henry Alvord, Chairman of the committee, a small collection, intended to present the commonly occurring minerals and rocks which by disintegration go to form the greater part of all soils and clays, was made up in part from the Mineralogical Department of the University and in part from our own Station collection. It comprised about fifty mineral and rock specimens arranged and properly labeled.

APPARATUS FOR MECHANICAL SOIL ANALYSIS—"SOIL ELUTRIATOR."

This instrument, devised by Professor Hilgard many years ago for the separation of soil particles (clay, silts, and sands) into groups of different degrees of fineness, promises to supersede all others; and in order that it might attract the attention of those interested in soil investigations, it was decided to place one of the instruments in the Laboratory alcove and put it in running order. A handsome nickel-plated elutriator was therefore made under the direction of Mr. Sladky, Instructor in the College of Mechanics of this University, and forwarded to Chicago.

The instrument and its workings were fully described in the last report of this Station.

EXHIBIT OF APPARATUS CONSTRUCTED IN THE COLLEGE OF MECHANICS.

The exhibit from the College of Mechanics consisted of three pieces of apparatus. Two of these were small alternate-current dynamos of about two horse-power each, designed by the students in the department; one wound for a constant current, the other for a constant potential. The other instrument was a mechanical regulator for maintaining a constant difference of potential between the brushes of a dynamo, and was designed by Instructor J. N. Le Conte. These machines were constructed by the students in the workshops of the college.

CEREALS AND FORAGE PLANTS.

A large collection of cereals, grasses, and forage plants, fiber plants, etc., was made up from the growths on the grounds of the Central *Station*. In outline this exhibit was as follows:

1. Cereals in sheaf, with threshed grain in bottles: Wheats, 129 varieties; spelts, 9 varieties; ryes, 7 varieties; oats, 39 varieties; barleys, 39 varieties.

2. Forage plants and grasses in bundles: Clovers, 13 species; grasses, 31 species; other forage plants, 19 species.

3. Fiber plants in bundles of stems: Flax, 8 varieties; ramie; esparto grass; New Zealand flax.

Each specimen was plainly labeled, and the collection as a whole very favorably commented upon.

THE MIDWINTER FAIR EXHIBIT.

The space allotted to the University of California occupied nearly the whole width of the north end of the Liberal Arts Building, and was divided into a number of alcoves, to each of which was assigned one or two of the departments of the University and the Professional Colleges. The whole presented a very fine and attractive exhibit of instruments, models, and material used in the class-room and museum.

One of these alcoves was occupied by the exhibit of the College of Agriculture and Experiment Stations; while another extensive wall space in the Horticultural Building was also used for a large exhibit of grain and fodder stuffs from the Station grounds. The necessarily limited space in the alcove precluded a very elaborate display from each of the branches of college and station work.

The specimens selected comprised the following:

SOILS.

The large samples, representing solid sections of soil from the surface to three feet in depth and four inches across, that had been boxed and sent to the World's Fair, were returned to us and again placed on exhibition in the alcove. They represented eighteen of the chief soil regions of the State, and are specially described in the preceding part of this report on exhibits. Another lot of specimens of soils in bottles was selected from the large collection of nearly 1,700 samples in the museum of the College of Agriculture. In this collection nearly every county in the State is represented to a greater or less degree, according to its rank as an agricultural region; thus some of the counties of the Great Valley have one or two hundred specimens each, while the Sierra mountain counties have but few samples.

From this collection about one hundred specimens were selected to represent as nearly as possible the varying soil features in each county, and were placed on shelves in the alcove.

AGRICULTURAL MAP OF THE STATE.

The large map on which had been outlined in different shades of color the chief agricultural regions of the State, and which had been sent to the World's Fair, was returned from Chicago in a somewhat mutilated condition, for it had been cut in two parts and tacked to the wall where exhibited. By remounting and varnishing, it was, however, made to present a fair appearance, and was placed in the Midwinter Fair exhibit.

SOIL ELUTRIATOR.

The elutriator, an apparatus designed for the separation of the mechanical ingredients comprising a soil, which was sent to the Chicago Exposition, was received and placed in the alcove. A small dynamo from the College of Mechanics was connected with it to supply motive power. To illustrate the results obtained by it, there were arranged on either side, a series of vials containing the eleven sediments of clay, silt, and sand, of varying diameters, obtained from each of twenty soils.

SEED-TESTING APPARATUS.

Another addition to the exhibit was the set of apparatus recently received from Vienna by the Station for the purpose of testing the purity and vitality of commercial seeds. It comprised:

1. A miniature separator or fanning-mill to remove the chaff and other light material from the seed.
2. A series of seed sieves with apertures of different diameters, placed on an agitator or rocker to facilitate the removal of weed and other objectionable seed, and the separation of fine from coarse seeds.
3. A germinator in the form of a cabinet supplied with zinc pans for the sprouting of the seed, and arrangements for heating and the regulation of the temperatures.

PHOTOGRAPHS AND MAPS.

A large number of the photographic views of the grounds, buildings, and special cultures at the several experiment stations had been taken during the previous season, and from these groups a few were selected and framed for the exhibit.

The colored maps and sketches of the grounds of the Foothill Experiment Station, made by the foreman, George Hansen, were also added to the exhibit. They show the surface contours of the grounds and mark the areas devoted to the various experiments.

CEREALS AND FORAGE PLANTS.

The collection that had been sent to the World's Fair was duplicated with a new growth for the Midwinter Fair, and under the charge of Professor Wickson and Captain Kellner was made to present a very interesting and creditable appearance upon the wall of the Horticultural Building. The exhibit, as enumerated on a previous page, comprised 223 varieties of cereals, both in sheaf and threshed grain in bottles; 63 varieties of forage plants in bundles, and 8 varieties of fiber plants.

Specimens of the wheat and barley grown on alkali land reclaimed by gypsum (described and illustrated on page 147) were also exhibited.

OLIVES, OLIVE PITS, OLIVE OIL, AND GRAPE SEED.

This exhibit was prepared by Messrs. Hayne and Bioletti, and thus described by the former: From the oil-room were selected samples of oil made from the crop of 1893–94. These were selected to show first, the differences in the oil made from various varieties; second, the differences

in the oil made from the same varieties grown on different soils and under different climatic conditions; third, the differences in the oil due to various processes in its preparation. The varieties thus tested were the Mission, Redding Picholine, Nevadillo Blanco, Rubra, Columbaro, Rock's Seedling No. 57, Oblonga, and frozen olives of several varieties mixed. In addition, there were over seventy samples of preserved olives, showing variety characteristics and local variations. These samples included the commoner California varieties and the best of the more recent foreign importations. With this last exhibit were a hundred and odd samples of olive pits from the collection used in the identification of doubtful varieties.

A model of a continuous, automatic, rapid-working oil separator recently invented in Italy was exhibited. This apparatus was of special interest, on account of the great saving of time and labor, as well as the lessening of the danger of rancidity that is as a rule attached to the present methods of oil manufacture.

The space allotted to the viticultural exhibit was so small that no wines or machinery could be taken from the wine cellar or viticultural laboratory, so the exhibit was, per force, confined to the above olive and olive oil samples, and grape seeds used in the identification of about fifty varieties.

ENTOMOLOGY.

The exhibit in entomology, under charge of Prof. C. W. Woodworth, "was designed to show especially the work of instruction in this department. It consisted of a desk of the form used in the entomological laboratory, and a set of wall cases, such as are used for specimens in the lecture-room. Upon the desk was shown the new orienting microscope, designed and built for our laboratory; a copy of the Laboratory Manual, used in the course in elementary and economic entomology; and a large jar illustrating the transformations of the honey bee. Upon the standard of the wall cases, a set of bottles illustrated the remedies recommended by us; and copies of the formulas were distributed during the fair. One of the wall cases represented the principal kinds of spraying nozzles; another, a dissection apparatus; ten were devoted to microscopical preparations of the anatomy of insects; and twelve boxes of beetles gave some idea of the collection of insects used in instruction in systematic and economic entomology."

FRUIT TREE CATALOGUE.

LIST OF VARIETIES REPRESENTED JANUARY 1, 1894, IN THE ORCHARDS OF THE FIVE EXPERIMENT STATIONS.

The following list of varieties of fruits now growing at the Central Station, Berkeley, and at the sub-stations, does not include new varieties in the nurseries, nor those that have lately been top-worked on seedling trees in the orchards. If these were also listed, the catalogue would be much longer, but it has been the aim of the compiler to include only those varieties that we know to be true to name and well established in the orchards. We hope to issue a complete descriptive catalogue at some future time, with especial reference to Pacific Coast seedling fruits, and including collections from Australia and other fruit-growing countries, that are now in the Station nurseries.

In deciding the questions of spelling and nomenclature, the following authorities have been chiefly consulted: Downing's "*Fruits and Fruit Trees of America*"; Thomas' "*American Fruit Culturist*"; Barry's "*Fruit Garden*"; and Wickson's "*California Fruits.*" For seedling fruits not yet described, the authority in every case is the originator or propagator. Reports of other experiment stations and of horticultural societies, and catalogues of almost every prominent nurseryman in the United States and Europe, have also been consulted.

The sign † denotes that the variety named was growing in the orchard of the given station January 1, 1894. The sign — denotes that it is not yet in the orchard; it may be in the Central Station nursery, to be in the outlying orchards by another year. Since every effort is made to select varieties adapted to the several stations, the orchards will never become entirely identical.

APPLES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Acme	—	†	†	—	—
Alexander	†	†	†	†	†
Amassia	†	—	—	†	—
Anisim	†	—	—	†	—
Arabskoe	†	—	—	—	†
Arkansas Black	—	†	†	†	—
Austrian	†	—	†	—	†
Autumn Sweet Bough	†	—	—	—	—
Australian Aphis-Proof	†	†	†	†	†
B. M. (from Budd)	†	—	—	—	†
Babbitt	†	—	—	—	—
Bailey's Sweeting	†	†	†	—	—
Baldwin	†	†	†	—	—
Beauty of Kent	—	†	†	—	—
Belle de Boskoop	—	—	—	—	†
Ben Davis	†	†	†	—	—
Benoni	†	†	†	—	—

APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Berenice	†	—	—	—	—
Berry Pippin	†	—	—	—	†
Black Warrior	†	—	—	—	—
Bledsoe	—	—	†	†	—
Blue Pearmain	—	—	†	—	—
Borken	†	—	—	—	—
Borsdoffer	†	—	—	—	—
Bradanoff	†	†	—	—	—
Brakefield Seedling	†	—	—	†	—
Brychenoff	†	—	—	—	†
Buckingham (Equinetely)	†	—	—	—	—
Canada Reinette	†	—	—	—	—
Cardinal	†	—	—	—	—
Carlough	—	—	†	—	—
Carolina Red June	†	—	—	—	—
Carolina Watson	†	—	—	—	—
Carter's Blue	†	—	—	—	—
Charlottenthaler	†	—	—	†	—
Chattahoochee	†	—	—	—	—
Chestatee	†	—	—	—	—
Clayton	†	—	†	—	—
Clyman's Pippin	†	—	†	—	—
Cogswell	†	—	—	—	—
Colvert	—	—	†	—	†
Cooper's Market	†	—	—	†	—
Count Orloff	†	—	—	—	—
Dahlonega	†	—	—	—	—
Dickinson	†	†	—	—	—
Disharoon	†	—	—	—	—
Dominie	†	—	—	—	—
Downing's Winter Maiden's Blush	†	—	—	—	†
Duchess of Oldenburgh	†	—	—	—	—
Duckett	†	—	—	—	—
Duke of Devonshire	—	—	†	—	†
Dutch Mignonne	†	—	—	—	—
Early Colton	†	—	—	—	—
Early Harvest	†	—	—	—	—
Early Joe	†	—	—	—	—
Early Ripe	—	†	†	—	†
Early Strawberry	—	†	†	—	—
Edward's Sweet	†	†	†	—	—
Esopus Spitzenberg	†	†	†	†	—
Everbearing	—	—	—	†	†
Excelsior	—	—	—	†	—
Fallawater	†	—	—	—	—
Fall Jenneting	†	—	—	—	—
Fall Pippin	—	†	†	—	—
Fall Wine	†	—	—	—	—
Fameuse (Snow)	†	†	†	†	†
Fanny	†	—	—	—	—
Forest	—	—	†	—	—
Gano	—	—	†	—	—
Garretson's Early	†	—	—	—	—
Gloria Mundi	†	†	†	†	—
Glowing Coal	—	—	†	—	—
Golden Russet (Am.)	†	—	—	—	—
Golden Russet (Eng.)	†	—	†	—	—
Grand Duke Constantine	†	—	—	—	—
Grand Sultan	†	—	—	—	—
Gravenstein	†	†	†	†	†
Grimes' Golden Pippin	†	†	†	†	—
Gros Vor	†	†	†	—	†
Gypsy Girl	†	—	—	—	—
Haas	—	†	†	—	—
Hall	†	—	—	—	—
Hargrove	†	—	—	—	—
Hawthornden	†	—	—	—	—
Herefordshire Beefing	†	—	—	—	—

APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Hoover	†	—	†	†	†
Hubbardston's Nonesuch	†	—	—	—	—
Huntsman	†	—	†	—	—
Hurlbut	—	†	—	—	—
Ingram	†	†	—	—	—
Jefferis	†	—	—	—	—
Jonathan	†	†	†	†	†
Julian	†	—	—	—	—
Keswick Codlin	—	—	—	—	—
King	—	†	†	—	—
King of Tompkins County	†	—	—	—	—
Kirkbridge White	†	—	—	—	—
Lady	†	†	—	†	—
Lady's Sweeting	—	†	†	—	—
Lankford	†	†	†	†	†
Lawver	—	†	†	†	†
Limber Twig	—	†	†	—	—
Lincoln	—	—	†	†	—
Lowell	†	—	—	—	—
Loy	—	†	†	†	—
Lyman's Pumpkin Sweet	†	—	—	—	—
Maiden's Blush	†	†	†	—	—
Mangum	†	—	—	—	—
Mann	—	†	†	—	—
Mammoth Black Twig	†	—	—	—	†
Marshall's Seedling	†	—	†	†	†
Maverack Sweet	†	—	—	—	—
McCloud's Family	†	—	—	—	—
McLellan	†	—	—	—	—
McMahon's White	—	†	†	—	†
Munson Sweet	†	—	—	—	—
Merkley's Red	†	—	—	—	—
Missouri Pippin	—	†	†	†	†
Montreal Beauty	—	—	†	†	—
Morton's Pearmain	—	†	†	—	—
Mother	†	†	†	—	—
Nantahalee	†	—	—	—	—
Nero	—	—	—	—	†
Nickajack	—	—	†	—	—
Northern Spy	†	—	†	†	†
Ortley	†	†	†	—	†
Pear Apple	†	—	—	—	—
Peck's Pleasant	†	†	†	—	—
Perry Russet	—	†	†	—	†
Persian	†	—	—	—	—
Pewaukee	†	—	†	†	†
Pigeon	†	—	—	—	—
Pine Stump	†	—	—	—	—
Pointed Pippin	†	†	†	†	†
Pomme Grise	†	—	—	—	—
Pomme Royale	†	—	—	—	—
Porter	†	†	†	—	—
Primate	†	—	—	—	—
Prior's Red	†	†	†	—	—
Pumpkin Sweet	†	—	—	—	—
Rambo	†	†	†	—	—
Rawle's Janet	—	†	—	—	—
Red Astrachan	†	†	†	†	†
Red Autumn Calville	†	—	—	—	—
Red Bietigheimer	—	—	†	†	†
Red Canada	†	†	—	—	—
Red-cheeked Pippin	—	†	†	—	—
Red Fall Pippin	†	—	—	—	—
Red June	—	—	†	—	—
Red Warrior	†	—	—	—	—
Red Winter Pearmain	—	—	†	†	—
Reinette Bauman	†	—	—	—	—
Reinette de Caux	—	†	—	—	†

APPLES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Rhode Island Greening	†	†	†	—	†
Ribstone Pippin	—	†	†	—	—
Rome Beauty	†	†	†	—	—
Rosa Ripka	†	—	—	—	†
Roxbury Russet	†	†	†	—	—
Ruby Gem	—	—	†	—	—
Seedless	†	—	—	—	—
Seek-No-Further	†	—	—	—	—
Serinka	†	—	—	—	—
Shackleford	†	†	†	—	—
Shannon	†	—	†	†	†
Sherwood's Favorite	†	—	—	—	—
Shirley	—	—	†	†	—
Skinner's Seedling	†	†	†	—	†
Smith's Cider	†	—	—	†	†
Smokehouse	†	—	—	—	—
Sonoma (Cook's Seedling)	—	†	†	†	†
Sops of Wine	†	—	—	—	—
Stark	—	†	†	—	—
Stevens' Rareripe	—	—	—	†	—
St. Lawrence	†	—	—	—	—
Stump	—	—	†	†	†
Summer Hagloe	†	—	—	—	—
Summer Queen	†	—	—	—	—
Swaar	†	†	†	—	—
Sweet June	†	†	—	—	—
Talman's Sweeting	†	†	†	—	—
Trenton Early	—	†	—	—	†
Twenty-Ounce	—	†	†	†	†
Vandevere	†	—	†	—	—
Violet	†	†	----------	†	—
Virginia Greening	†	—	—	—	—
Wagener	†	†	†	—	—
Walbridge	—	†	—	—	†
Waldo	†	—	—	—	—
Wall	†	—	—	—	—
Wealthy	—	†	†	†	†
Wells Sweet	†	—	—	—	—
White Astrachan	—	—	—	†	—
White Pippin	†	—	—	—	—
White Winter Pearmain	†	†	†	†	†
Willow Twig	†	—	—	—	—
Winesap	—	†	†	—	—
Winter Banana	—	†	†	—	—
Wolf River	—	†	†	†	—
Wythe (Pittsburgh Pippin)	—	—	—	†	—
Yellow Bellflower	†	—	†	†	—
Yellow Newtown Pippin	—	†	†	†	†
Yopp's Favorite	†	—	—	—	—
York Imperial	—	†	—	—	—
Zuzoff Winter	†	—	—	—	†
12 M (from Budd, Iowa)	†	†	†	—	—
15 M (from Budd, Iowa)	†	†	†	—	—

CRAB APPLES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Chicago	†	—	—	—	—
Coral	†	—	—	—	—
Currant	†	—	—	—	—
Hew's Virginia	†	—	—	—	—
Hyslop	†	†	†	—	†
Lady	†	—	—	—	—
Large Red	†	—	—	—	—
Large Yellow	†	—	—	—	—
Malus Carda	†	—	—	—	—
Malus Floribunda Atropurpurea	†	—	—	—	—
Malus Kaida	†	—	—	—	—
Montreal Beauty	†	—	—	—	†
Oblong	†	—	—	—	—
Red Siberian	†	—	†	—	—
Ringo	†	—	—	—	—
Transcendent	†	†	†	—	†
Whitney	—	—	†	†	†
Yellow Siberian	—	—	—	†	†

ALMONDS.

Bidwell's Mammoth	—	†	†	†	—
Commercial	—	†	†	—	†
Coppin's Seedling	†	—	—	—	—
Drake's Seedling	—	†	†	—	†
Flat-Fruited	—	†	†	—	†
Golden State	—	†	†	—	†
Hatch's Seedling No. 2	†	—	—	—	—
Harriott's Seedling	—	†	†	†	—
I X L	—	†	†	†	†
King's Soft-shell	—	†	†	—	†
Languedoc	†	†	†	—	†
Lewelling Prolific	†	†	—	—	†
Loomis' Seedling	†	—	—	—	—
Marie Dupreys	—	†	†	—	†
Ne Plus Ultra	—	†	†	†	†
Nonpareil	—	†	†	†	†
Paper-shell	—	†	†	†	†
Pistache	—	†	†	—	†
Routier's Twin	—	†	—	†	—
Silver-shell	—	—	—	—	†
Sultana	—	†	†	—	†
Texan Prolific					
Wolfskill	—	†	—	—	—

APRICOTS.

Alberge de Montgamet	†	—	—	†	—
Beauge	—	†	†	†	—
Blenheim (Shipley)	†	†	†	†	†
Boulbon	—	†	—	†	—
Briggs' White	†	—	—	—	—
Breda	†	†	†	†	—
Brigitta's French	—	†	—	—	†
Canino Grosso	†	†	—	†	—
De Coulorge	†	†	†	†	†
Early Golden	†	—	†	—	—
Early Moorpark	†	—	—	†	†
Early Rivers	—	†	—	—	†
Esperen	—	†	—	—	—
Flickinger	—	†	—	†	†
Gold Dust	—	†	—	—	†
Gooley	—	†	—	—	†
Hemskirke	†	†	†	†	†

APRICOTS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Hind's	—	—	†	—	†
Hubbard	—	†	†	—	†
Jamucett	†	—	—	—	—
Kaisha	†	†	†	†	†
Kell's Peach	—	†	†	†	—
King's Seedling	†	—	—	†	—
Large Early	†	—	—	†	—
Luizet	—	†	†	†	†
Long Red	†	—	†	†	—
Malcom's Breda	†	—	†	—	—
Montgamet	—	†	†	†	†
Moorpark	—	†	†	†	†
Musch-Musch	—	—	†	†	—
Musk—Early	—	—	—	—	†
Newcastle	—	†	†	—	†
Orange	—	—	†	—	—
Oullin's Golden	†	†	—	†	†
Peach	—	†	†	†	—
Pringle	—	—	†	†	†
Purple, or Black	†	†	†	—	—
Red Masculine	†	†	†	†	—
Royal	—	†	†	†	—
Routier's Peach	—	—	†	†	—
Russian	†	—	—	†	—
Turkey	†	†	†	—	†
St. Ambroise	†	†	†	†	†
Sardinian	†	†	†	†	†
Shensi	†	†	†	†	†
Spark's Mammoth	†	†	†	—	—
Smith's Triumph	—	—	†	†	†
Viard	—	—	†	†	†

CHERRIES.

Abeso	—	—	†	†	†
Amarelle Bunt	†	†	†	—	†
American Heart	†	—	—	—	—
Baumann's May	—	†	†	—	—
Belle Crown	†	†	—	—	—
Belle d'Orleans	—	†	†	—	—
Belle Magnifique	†	†	†	—	†
Bessarabian	—	—	—	†	—
Bigarreau Noir Hâtif	†	—	—	†	—
Bigarreau Riverchon	†	—	—	—	—
Black Eagle	—	—	†	—	—
Black Mastodon	—	†	†	—	—
Black Tartarian	†	†	†	†	†
Brant	†	—	—	—	—
Burr's Seedling	—	†	†	—	—
Buttner's Yellow	†	—	—	—	—
California Advance	†	†	—	—	—
Centennial	†	†	†	—	†
Chapman	†	—	†	—	—
Cleveland Bigarreau	—	†	—	—	—
Coe's Transparent	—	†	†	—	—
Duchesse de Palluau	—	†	†	—	—
Downer's Late Red	†	†	—	—	—
Early Lamaurie	†	—	—	—	—
Early Purple Guigne	—	†	†	—	—
Early Richmond	—	†	—	—	—
Early Rivers	—	†	†	—	—
Elton	†	†	—	—	†
Empress Eugenie	—	†	†	†	—
English Morello	—	†	†	—	—
Frogmore Bigarreau	†	—	—	†	—
George Glass	†	†	†	†	†

CHERRIES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-(Chino.)
Governor Wood	†	†	†	—	—
Great Bigarreau	—	†	†	—	—
Gridley	†	—	—	—	—
Griotte Précoce	†	†	—	†	†
Guigne Tres Précoce	—	†	†	—	†
Kanawha	†	—	—	—	—
King's Amarelle	†	†	†	†	†
Knight's Early Black	†	†	†	†	—
Lewelling	—	†	†	—	—
Lincoln	—	†	—	—	—
Major Francis	—	†	†	—	—
Manning's Mottled	†	—	—	—	—
May Duke	†	†	†	—	—
Merveille de Septembre	†	—	—	—	—
Monstreuse de Mezel	†	—	—	—	—
Napoleon Bigarreau	—	†	†	—	†
Newcastle	—	†	—	—	—
Nouvelle Royale	—	†	—	—	—
Olivet	—	†	†	—	—
Oregon	—	—	†	—	—
Pontiac	—	†	†	—	—
Purity	—	†	†	—	—
Qutorka	†	—	†	—	†
Reine Hortense	—	—	†	—	—
Richmond	—	—	—	—	†
Rockport Bigarreau	†	†	†	—	†
Rostraver Bigarreau	†	—	—	—	—
Schmidt's Bigarreau	—	†	†	—	—
Slanka	†	—	—	†	†
Tarascon Early	—	†	—	—	—
Thompson's Seedling	†	—	†	—	—
Tradescant Black Heart	—	†	†	—	—
Vilne Sweet	—	—	—	—	†
Werder's Early Black Heart	—	†	†	—	—
Willamette	—	†	†	—	†
Windsor	—	†	†	—	—
Yellow Glass	†	†	†	†	†
Yellow Spanish	—	†	†	—	—

CHESTNUTS.

American Sweet	—	†	†	—	—
Italian	—	†	—	—	†
Japan Giant	—	—	—	—	†
Marron de Lyon	—	†	—	—	†
Numbo	—	†	—	—	†

CITRON.

Amalfi	—	—	—	—	†
Sorrento	—	—	—	—	†

FIGS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Abondance Précoce	—	†	—	†	†
Agen	—	†	†	†	†
Angelique	—	†	†	†	†
Bellona	—	—	—	—	†
Black Bourjassotte	—	†	†	†	—
Black California	—	†	†	†	—
Black Dattato	—	†	—	†	†
Black Havana	—	—	—	—	†
Black Ischia	—	†	—	†	†
Black Marseilles	—	†	†	†	—
Bourjassotte Gris	—	—	—	—	†
Bourjassotte Panachée	—	—	—	—	†
Breba	†	†	—	†	†
Brianzola	—	†	—	—	†
Brogiotto (black)	—	—	—	—	†
Brogiotto (white)	—	—	—	†	†
Brown Turkey	—	†	†	†	†
Brown Ischia	—	†	—	†	†
Brunswick	—	†	†	†	†
Buissonne	—	—	—	—	†
Capri (wild fig)	—	†	†	†	†
Cernica	†	†	†	†	—
Col di Signora Bianca	—	†	—	†	†
Col di Signora Nero	—	†	†	†	—
Coucourelle Noire	—	—	—	—	†
Dalmatian	—	†	†	†	—
De Constantine	—	†	†	†	†
Dorée Narbus	—	†	—	†	—
Drap d'Or	—	†	—	†	—
Du Roi	†	†	†	†	†
Early Violet	—	†	—	†	—
Ford's Seedling	—	—	—	—	†
Gros Gris Bifere	—	†	—	†	†
Grossale	—	—	—	†	—
Guiglione	—	†	—	—	†
Hirtu du Japon	†	†	†	†	†
Ladora	—	†	—	†	†
Magdalen	—	—	—	—	†
Monaca Bianca	—	†	†	†	†
Negro Largo	—	†	†	†	†
Nepolitaine	—	—	—	—	†
Noir Moutier	—	—	—	—	†
Osborne Prolific	—	†	†	†	†
Pacific White	†	—	—	—	—
Pagandiere	—	—	—	—	†
Pasteliere	—	†	†	†	†
Petrovaca	†	†	—	†	—
Rargigna	†	†	—	†	†
Rocardi	—	†	†	†	—
Ronde Noir	†	†	†	†	†
Ronde Violette Hâtive	—	†	—	†	†
Royal Vineyard	—	—	—	†	†
Rubado	—	†	—	—	†
San Pedro	—	†	†	†	†
Sanvito	—	†	—	—	—
Smyrna (California)	—	†	—	†	†
Smyrna (Bulletin)	—	†	†	†	†
Trojano	—	†	—	†	†
Verdal Longue	—	—	—	—	†
White Adriatic	†	†	†	†	†
White Genoa	—	†	†	†	†
White Ischia	—	†	†	†	†
White Marseilles	—	†	†	†	†
White Nerii	†	—	—	—	—
White Smyrna	†	†	—	—	†
Yellow Celestial	—	—	—	†	†
Zimeia	†	†	—	†	—

LEMONS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Bonnie Brae	—	—	—	—	†
Eureka	—	—	—	—	†
Genoa	—	—	—	—	†
Lisbon	—	—	—	—	†
Royal Messina	—	—	—	—	†
Villafranca	—	—	—	—	†

MULBERRIES.

Alba	†	—	†	†	—
Downing's	†	†	†	†	—
Italian Dwarf	†	†	†	—	—
Lhoo	†	†	†	†	—
Multicaulis	†	†	†	†	—
Moretti	†	†	†	—	—
Nagasaki	†	†	†	†	—
Persian	†	—	†	†	—
Russian	†	—	†	†	—
Stubbs	†	—	—	—	—

NECTARINES.

Balgowan	—	—	†	—	†
Boston	—	—	†	†	—
Coosa	†	—	—	—	—
Downton	†	—	†	†	†
Duc de Vitry	†	—	†	—	—
Early Newington	†	†	†	†	†
Early Violet	—	†	—	†	—
Elruge	—	—	—	—	†
Hardwicke	—	—	†	†	—
Lord Napier	†	†	†	†	—
Monicourt Vinous	†	—	—	—	—
New White	†	†	†	†	—
Olmstead	—	†	†	—	†
River's Orange	†	—	—	—	†
Red Roman	—	—	†	—	†
Stanwick	—	—	†	†	†
Victoria	†	†	†	†	†

ORANGES.

Florida Sour	—	—	—	†	†
Hart's Tardive	—	—	—	—	†
Homosassa	—	—	—	—	†
Jaffa	—	—	—	—	†
King	—	—	—	—	†
Kin-Kin (round)	†	—	—	—	—
Kin-Kin (oval)	†	—	—	—	†
Kino-Kuni	—	—	—	—	†
Konah	—	—	—	—	—
Magnum Bonum	—	—	—	—	†
Malta	—	—	—	—	†
Mediterranean Sweet	—	—	—	—	†
Oonshiu	†	†	—	†	†
Parson Brown	—	—	—	—	†
Pineapple	—	—	—	—	†
Ruby Blood	—	—	—	—	†
Seedlings in variety	†	†	—	†	†
St. Michaels	—	—	—	—	†
Tangerine	—	—	—	—	†
Washington Navel	—	—	—	—	†

PEACHES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Acton Scott	—	†	—	—	—
Alberge	†	†	—	†	—
Albright's Cling	—	†	†	—	—
Alexander	—	†	†	†	†
Amelia	—	†	—	†	—
Amsden's June	—	†	†	—	†
Atlanta	†	—	—	—	†
Baldwin's Late	—	†	—	†	†
Beer's Smock	—	†	†	†	—
Belle Bauce	†	†	†	†	—
Belle Bouquet	—	†	—	—	—
Belle Coquette	†	—	—	—	—
Belle de la Croix	—	†	—	†	—
Belle Douai	†	—	†	†	—
Bergen's Yellow	†	—	—	—	—
Bilyeu's Late	†	†	—	—	—
Bishop's Early	—	†	—	†	—
Bonanza	—	†	†	†	—
Brandywine	—	†	†	†	—
Brevoort	†	—	—	†	—
Briggs' May	†	†	†	—	†
Brook's Butte	—	†	†	—	†
Buck's Prolific	†	†	†	—	†
Burke Cling	—	—	—	†	†
California Cling	—	†	†	†	†
Canada Cling	†	†	—	†	—
Carmine	†	†	—	—	†
Chair's Choice	—	†	—	†	—
Chinese Cling	—	†	†	†	†
Chevreuse Hâtive	†	†	—	†	—
Cole's Early Red	†	†	—	—	—
Columbia	—	†	†	—	—
Comet	†	—	—	—	†
Cooledge's Favorite	†	†	†	†	†
Crawford Early	—	†	†	†	†
Crawford Late	—	†	†	†	†
Crimson Beauty	—	†	†	†	—
Crimson Galande	†	—	—	—	—
Crosby	†	—	—	†	—
Dagmar	†	—	—	—	†
Delaney Heath Cling	†	—	—	—	—
De la Regandiere	—	†	—	—	—
Dr. Hogg	†	—	—	†	—
Dr. Pilkington (seedling)	†	—	—	†	†
Early Albert	—	†	—	—	—
Early Alfred	†	—	—	†	†
Early Beatrice	†	†	—	—	—
Early Charlotte	†	†	—	—	—
Early Louise	†	—	—	—	—
Early Grosse Mignonne	—	—	†	—	—
Early Rivers	—	†	†	†	—
Early Rose	†	†	—	†	—
Early Savoy	†	†	—	—	—
Early Silver	†	†	—	—	—
Early Victoria	†	†	—	—	—
Early York	†	†	—	—	—
Edith Cushing	†	—	—	—	—
Elberta	—	†	†	†	—
Ford's Improved	—	—	—	†	†
Foster	†	†	†	†	†
Geary's Hold On	—	†	†	—	—
George's Late Cling	—	†	†	†	—
George IV	†	†	—	—	—
General Bidwell (of California)	—	†	†	—	—
General Lee	†	—	—	—	—
Golden Cling	—	—	—	†	—
Gold Dust Cling	†	†	—	†	†
Governor Briggs	—	—	—	†	—

PEACHES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Governor Garland	—	†	†	†	†
Gresham	—	—	—	†	†
Grover Cleveland	—	†	†	†	—
Grosse Mignonne	—	—	—	†	†
Haine's Early	—	—	†	†	†
Hale's Early	—	—	—	†	—
Heath Cling	†	†	—	—	—
Heath Free	†	—	—	—	—
Henrietta	†	†	†	†	†
Hisk's Seedling	†	†	—	—	—
Hill's Madeira	†	—	—	—	—
Honest Abe	—	†	†	—	—
Honey Cling	—	†	†	—	—
Indian Blood	—	†	†	†	†
Italian Dwarf	—	—	†	—	—
Jacques Rareripe	†	†	—	—	—
Japan Blood	—	†	†	—	—
Jennie Worthen	—	†	†	†	—
Jones' Seedling	†	—	—	—	†
Lady Palmerston	†	—	—	—	—
La Grange	—	†	†	†	—
Large Early Mignonne	†	—	—	†	—
Large Early York	†	†	†	†	†
Large White Cling	—	†	†	—	—
Late Admirable	—	†	†	†	†
Late Morris White	†	—	—	—	†
Lemon Cling	†	†	†	†	†
Lemon Free	—	†	—	†	—
Leopard	†	—	—	—	—
Leopold I	†	—	—	—	—
Lovell	—	†	†	†	†
Lovett's White	†	—	—	†	†
Lyon Cling	—	—	†	—	—
Malta	†	—	—	—	—
Mammoth Melocoton	†	—	—	—	—
Marshall's Late	—	—	—	†	†
Mary's Choice	—	†	—	†	—
McDevitt's Cling	—	†	†	—	†
Magdala	—	—	—	†	—
McKevitt's Cling	†	†	†	†	†
McKevitt's Free	—	—	—	—	†
Miss Lola	—	†	—	—	†
Monstreuse de Doue	†	—	—	—	—
Moore's Favorite	†	†	†	—	—
Morris White	†	†	†	†	†
Mountain Rose	†	†	†	†	†
Mrs. Brett	—	†	†	—	—
Muir	†	†	†	†	†
Muscogee	†	—	—	—	—
Newhall	—	†	†	†	†
Newington	—	†	†	—	—
Nichols' Orange Cling	†	†	†	†	†
Noblesse	—	†	†	†	—
Oldmixon Cling	†	†	†	†	†
Oldmixon Free	†	†	†	†	—
Pansy Pabor	—	†	—	†	†
Peen-To	†	†	—	†	—
Picquet's Late	†	†	†	†	†
President	†	—	†	—	—
Pucelle de Malines	†	†	—	†	†
Pymrod	†	—	—	—	—
Raymackers	†	—	—	†	—
Red River	—	†	—	†	—
Richmond	†	†	—	†	—
Roseville Cling	†	—	—	†	—
Royal George	—	†	†	†	—
Royal Kensington	†	—	—	—	—
Runyon's Orange Cling	—	†	†	—	†

PEACHES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Salway	†	†	†	†	†
Scrugg's	—	†	—	†	—
Seller's Cling	†	†	†	†	†
S. G. French	—	†	—	†	—
Shark's Prolific	—	—	—	—	†
Schumacker	—	†	†	†	—
Smock Late Free	†	†	—	†	†
Sneed	†	†	†	—	†
Snow	†	—	—	†	—
Spottswood	†	—	—	—	—
Staley's Seedling	†	—	—	—	†
St. Ascycles	—	—	—	—	†
Strawberry	†	†	†	—	—
Stump the World	†	†	†	†	†
Surpasse Melocoton	†	—	—	—	—
Susquehanna	—	†	†	†	†
Thissell's Free	—	†	†	†	†
Tippecanoe	†	—	—	—	†
Troth's Early	†	—	—	—	—
Tuscany Cling (Tuskena?)	†	†	†	—	—
Ulatis	—	†	†	†	—
Van Buren's Golden Dwarf	†	—	—	—	—
Wager	—	†	†	—	—
Ward's Late Free	†	†	†	†	†
Waterloo	—	†	†	†	†
Wheatland	†	†	†	†	—
White Imperial	†	—	—	—	—
White Melocoton	†	†	—	—	—
White Tuscan Cling	—	†	—	—	—
Wilkins' Cling	—	†	†	†	—
Wonderful	—	†	—	†	—
Yellow St. John	†	†	†	†	†
Yellow Tuscany Cling	†	—	—	†	†

PEARS.

America	†	—	—	—	—
Amire Joannet	†	—	—	—	—
Ananas d'Eté	†	—	—	—	—
André Desportes	—	†	—	†	—
Andrews	†	—	—	—	—
Anna Nelis	†	†	†	—	†
Anne Ogereau	—	—	—	†	—
Augustus Dana	†	—	—	—	†
Baronne de Mello	†	—	—	—	†
Bartlett	†	†	†	†	†
Beaupresent d'Artois	†	—	—	†	—
Belle Lucrative	†	—	†	†	—
Belle Williams	†	—	—	—	—
Bergamotte Cadet	†	—	—	—	—
Bergamotte d'Esperen	†	—	—	—	—
Beurré Amande	†	—	—	—	—
Beurré Bosc	†	—	†	†	†
Beurré Clairgeau	†	†	†	†	†
Beurré d'Amanlis	—	†	†	†	—
Beurré d'Anjou	†	—	†	†	†
Beurré d'Aremberg	†	—	—	—	—
Beurré Assomption	†	—	—	†	†
Beurré de Waterloo	†	—	—	†	—
Beurré Diel	†	—	†	†	—
Beurré Easter	†	—	†	†	†
Beurré Giffard	†	—	†	†	†
Beurré Golden of Bilbao	†	—	—	—	†
Beurré Goubalt	†	—	—	—	—
Beurré Gris	—	—	†	†	†
Beurré Gris d'Hiver Nouveau	†	†	—	†	—

PEARS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Beurré Hardy	†	—	†	†	†
Beurré Langlier	†	—	—	†	—
Beurré Précoce	†	—	—	—	—
Beurré Sterkmans	†	—	—	—	—
Beurré Superfin	†	—	†	†	—
Bezi Sanspareil	†	—	—	—	—
Black Worcester	—	—	†	†	—
Blanquette	—	†	—	—	†
Bloodgood	†	†	—	†	—
Bonne d'Ezée	†	—	—	—	—
Bonne du Puits Ansault	†	—	—	—	†
Bonne Sophie	†	—	—	—	—
Brandywine	†	—	—	—	—
Brockworth Park	†	†	†	—	†
B. S. Fox	—	—	†	†	†
Buffum	†	—	—	—	—
Calabasse Monstreuse	†	—	—	—	—
Canandaigua	†	—	—	—	—
Chaptal	†	—	—	—	—
Chaumontel	†	—	—	—	—
Clapp's Favorite	†	†	†	†	†
Cole	—	†	†	†	†
Colonel Wilder	—	—	—	†	—
Columbia	†	—	†	†	—
Conseiller de la Cour	†	†	†	†	†
Courte Queue d'Automne	†	—	—	—	†
Dana's Hovey	†	—	†	—	—
Dearborn's Seedling	†	—	†	†	—
De Tongres	†	†	†	†	†
Directeur Alphand	—	†	—	—	†
Dix	†	†	†	†	—
Doyenne Boussock	†	—	†	—	—
Doyenne d'Alençon	†	†	†	†	—
Doyenne d'Eté	†	—	†	†	—
Doyenne du Comice	†	—	†	†	—
Doyenne Robin	†	—	—	—	—
Doyenne Sieulle	†	—	—	—	—
Doyenne White	†	—	—	†	—
Dr. Reeder	†	—	—	†	†
Duchesse d'Angoulême	†	—	†	†	†
Duchesse de Mouchy	†	—	—	—	†
Duchesse de Berry d'Eté	†	—	—	—	—
Duchesse d'Orleans	†	—	—	—	†
Duchesse of Bordeaux	†	—	—	—	†
Duchesse Précoce	†	—	—	—	—
Duhamel du Monceau	†	—	—	—	†
Emile de Heyst	†	—	—	†	—
Epine Dumas	†	—	—	—	†
Eugene Appert	†	—	—	—	†
Figue d'Alençon	†	—	—	—	†
Flemish Beauty	†	†	—	†	†
Fondante de Noël	†	—	—	—	†
Fondante Fougere	†	—	—	—	—
Forelle	†	†	†	†	—
Frederick Clapp	—	†	—	†	†
Fulton	†	—	—	—	—
Gansel's Bergamotte	—	—	†	†	—
Glout Morçeau	†	—	†	†	†
Gratiola, of Jersey	†	—	—	—	—
Gray Doyenne	†	—	†	†	†
Hawaii	†	—	—	—	—
Henry IV	†	—	†	†	†
Howell	†	—	—	†	†
Idaho	†	—	†	†	—
Inconnue	†	—	—	—	—
Jalousie de Fontenay Vendée	†	—	—	—	†
Jaminette	†	—	†	†	—
Japan Seedlings	—	†	†	—	—

PEARS—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare)	Southern California Station. (Pomona-Chino.)
Jean de Witte	—	—	†	†	—
Jones' Seedling	†	—	—	—	†
Josephine de Malines	—	†	†	†	—
Keiffer	†	†	†	†	—
Kennedy	—	—	†	†	—
Kingsessing	†	—	—	—	—
Kirtland	†	—	—	—	—
Lankford	†	—	†	—	—
Lawrence	†	—	†	†	†
Lawson or Comet	—	—	†	†	†
Le Conte	†	†	†	†	†
Levard	†	—	—	—	†
Liberale	†	—	—	—	—
Louise Bonne de Jersey	†	—	†	†	—
Louis Vilmorin	†	—	—	—	†
Madame Cuissard	†	—	—	—	—
Madame Loriol de Barney	†	—	—	—	†
Madame Treyve	†	—	—	—	†
Madeleine	†	†	†	†	†
Manning's Elizabeth	†	—	—	—	—
Maréchal Vaillant	†	—	—	—	†
Marie Louise d'Uccles	†	—	—	—	†
Maurice Desportes	†	—	—	—	—
Mount Vernon	†	†	†	†	†
Moyamensing	†	—	—	—	—
Nantais	†	—	—	—	—
Napoleon	†	—	—	—	†
Nouveau Poiteau	†	†	†	†	—
Onondaga	—	—	†	†	—
Osband's Summer	†	—	†	†	†
Oswego Beurré	†	—	—	—	—
Ott	†	—	—	—	—
Paradise d'Automne	†	†	†	†	†
Passe Colmar	†	—	—	—	†
Pater Noster	†	—	—	—	†
Paul Ambre	†	—	—	—	—
P. Barry	†	†	†	†	†
Petite Marguerite	†	—	—	—	—
Pitmaston's Duchesse d'Angoulême	†	—	—	—	†
Pound	†	—	—	†	—
Pratt	†	—	—	†	—
Prince's St. Germain	†	—	—	—	—
Rostiezer	†	—	—	—	—
Rousselet Stuttgart	†	—	—	—	—
Rutter	†	—	—	—	—
Santa Ana	†	—	—	—	—
Sarah	†	—	—	—	†
Seckel	†	—	†	†	†
Sheldon	†	†	—	†	—
Smith's Hybrid	—	—	—	—	—
Souvenir d'Esperen	†	—	—	—	†
Souvenir du Congrès	†	—	†	†	†
St. André	†	—	—	—	†
Star of Bethlehem	—	—	—	—	†
St. Crispin	†	—	—	—	†
Steven's Genessee	†	—	—	—	—
St. Germain	†	—	—	—	—
St. Michael Archange	†	—	—	—	†
Swan's Orange	†	—	—	—	—
Theresa Appert	—	—	—	—	†
Tyson	†	—	†	†	†
Urbaniste	—	—	†	†	—
Van Mons' Leon le Clerc	—	—	†	†	†
Vicar of Winkfield	†	—	—	†	†
Washington	†	—	—	—	—
Winter Nelis	†	†	†	†	†
Winter Seckel	—	†	†	†	†
Williams d'Hiver	†	—	—	—	†

PLUMS AND PRUNES.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Autumn Gage	†	†	†	—	—
Autumn Compôte	†	—	—	—	—
Barbat d'Ente	†	—	—	†	†
Barry	—	—	†	—	—
Bassford Prune	—	†	—	—	—
Bavay's Green Gage	—	†	†	†	†
Belgian Purple	†	†	†	—	†
Belle de Septembre	†	†	†	†	†
Blackman	†	†	†	†	—
Bleeker's Gage	†	†	†	—	—
Blue Damson	†	†	†	†	†
Botan	—	†	†	†	†
Botankio	†	†	†	†	†
Bradshaw	†	†	†	†	†
Brignole	—	†	†	—	†
Bryanston's Gage	†	—	†	†	†
Bulgarian Prune	†	†	†	†	†
Burbank	†	†	†	—	†
Caddo Chief	—	—	—	†	—
California Red	—	—	—	†	—
Chabot Blood	†	†	—	†	—
Chapman's Black	—	—	—	†	—
Cherry	—	†	—	†	—
Clyman	—	†	†	†	—
Coe's Golden Drop	†	†	†	†	†
Coe's Late Red	—	†	—	†	†
Columbia	†	†	†	†	—
Copper	†	†	†	†	†
Cumberland	†	—	—	—	—
Czar	—	†	†	†	†
Damas Noir	—	—	†	†	—
Datte de Hongrie	†	†	†	†	†
D'Ente de Puymirol	†	†	—	—	†
Dennison's Superb	†	—	†	—	†
Diamond	†	†	†	†	—
Diaprée Rouge	—	†	†	†	—
Drap d'Or d'Esperen	†	†	†	—	†
Duane's Purple	†	†	†	†	†
Early Gilt	†	—	—	—	—
Early Golden Drop	—	†	—	†	—
Elmore	—	†	†	†	—
Fellenberg (Italian)	†	†	†	†	†
General Hand	†	†	†	†	†
German Prune	†	†	†	†	†
Glaister	†	—	†	—	†
Golden Beauty	—	—	—	†	—
Golden Prune	†	—	†	†	—
Goliath	†	—	†	—	†
Grand Duke	—	†	—	—	†
Green Gage	†	—	†	†	†
Grosse Prune d'Agen	†	†	†	†	†
Guthrie's Late Green	†	†	†	†	†
Hungarian Prune	—	—	—	†	—
Hattankio	—	—	†	—	—
Holman	—	†	†	—	—
Ickworth's Imperatrice	—	†	†	†	†
Imperial Gage	†	†	†	†	—
Ive's Autumn	†	†	†	—	†
Japan No. 3	—	—	†	—	—
Jefferson	†	†	†	†	†
Judson	†	—	—	†	†
Kelsey	†	†	†	†	†
Lawrence's Favorite	†	—	—	†	—
Leipsic	†	†	†	†	—
Lombard	†	†	†	—	†
Lone Star	†	—	—	†	—
Long-Fruited Japan	†	†	†	—	†
Lot D'Ente	†	†	—	—	†

PLUMS AND PRUNES—Continued.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
Lucombe's Nonesuch	†	—	†	†	†
Marianna	†	†	†	†	†
Masu	†	†	†	†	†
McLaughlin	†	†	†	†	†
Monroe Gage	†	†	†	†	†
Morocco	†	†	†	†	†
Myrobalan	†	—	†	—	—
New Black Bullace	†	—	—	†	†
Ogon	†	†	†	—	—
Ontario	†	—	†	†	—
Orange	†	†	†	—	†
Oullin's Golden	—	†	†	†	†
Peach Plum	†	†	†	†	—
Perdrigon Blanc	—	†	†	†	†
Petite Prune d'Agen (French Prune)	†	†	†	†	†
Peter's Yellow Gage	†	†	†	†	†
Précoce de Bergthold	—	†	†	†	†
Prince Engelbert	†	†	†	†	†
Prince of Wales	—	†	†	†	†
Prince's Yellow Gage	†	†	†	—	†
Prunus Simoni	†	†	†	†	†
Purple Favorite	—	†	—	—	—
Prunus Pissardi	—	—	—	†	—
Quackenboss	†	†	†	†	†
Red Gage	—	—	†	—	—
Red Magnum Bonum	†	†	†	†	†
Reine Claude de Bavay	†	†	†	†	†
River's Early Prolific	—	—	†	†	†
Robe de Sergent	—	†	†	†	—
Ronald's Fancy	†	†	—	†	—
Royale de Tours	†	†	†	†	—
Royal Hâtive	—	†	†	†	†
Ruby	—	†	—	†	—
Saint Catherine	—	†	†	†	†
Saint Martin	†	†	†	†	†
Satsuma	—	—	—	†	—
Shiro	—	—	†	—	—
Shropshire Damson	†	†	†	†	†
Silver Prune	†	†	†	†	—
Smith's Orleans	—	†	†	—	†
Stark's Green Gage	—	†	—	†	—
St. Lawrence	†	†	†	—	†
Tennant Prune	†	—	—	—	—
Tragedy	†	†	†	—	†
Transparent Gage	†	—	—	—	—
Uncle Ben	—	—	†	—	—
Ungarish Prune	†	—	†	†	—
Victoria	—	†	†	†	†
Wangenheim	†	†	†	†	—
Washington	†	†	†	†	†
Weedsport	†	—	—	—	—
Wild Goose	†	—	—	—	—
Winesour	†	†	—	—	†
Wyat	†	†	†	†	—
Yellow Gage	†	†	†	†	†
Yellow Magnum Bonum	†	†	†	†	†

PERSIMMONS.

Variety.	Central Station. (Berkeley)	Foothill Station. (Jackson.)	S. Coast R. Station. (Paso Robles.)	San Joaquin Valley Station. (Tulare.)	Southern California Station. (Pomona-Chino.)
American	†	†	—	†	†
Japanese—Dai Dai Maru	†	†	—	—	—
Japanese—Hyakume	†	†	—	—	—
Japanese—Kuro Kume	†	†	—	—	—
Japanese—Layi	†	†	—	—	—
Japanese—Tsuro Noko	†	†	—	—	—
Japanese—Yemon	†	†	—	—	—

QUINCES.

Angers	—	†	—	—	—
Chinese	†	†	†	—	—
Champion	—	†	†	—	—
Meech's Prolific	—	—	†	—	—
Orange	—	†	—	†	—
Portugal	—	—	†	—	—
Rea's Mammoth	—	†	†	—	—
Smyrna	—	—	—	—	†

WALNUTS.

Black Californian	—	†	—	†	—
Black Eastern	—	†	—	—	—
Common English	—	†	—	†	†
French Bijou	—	†	—	—	†
French Chaberte	—	†	—	—	†
French Franquette	—	†	—	—	†
French Mayette	—	†	—	—	†
French Mésange	—	—	—	—	†
French Meylan	—	—	—	—	†
French Parisienne	—	—	—	—	†
French Præparturiens	—	†	—	—	†
French Præparturiens (large-fruited)	—	—	—	—	†
French Præparturiens (cluster)	—	—	—	—	†
French Præparturiens (weeping)	—	—	—	—	†
French Serotina	—	†	—	—	†
French Vourey	—	†	—	—	†
Japanese (Sieboldii)	†	—	—	—	—
Persian (Kaghazi)	—	†	—	—	—
Santa Barbara Soft-shell	—	—	—	†	—

THE LIBRARY AND READING-ROOM OF THE CENTRAL EXPERIMENT STATION.

This is an age of specialist publications, and much that is of very great value only appears in pamphlets and periodicals. The Agricultural Department receives all the publications of the experiment stations in the United States and other countries. These alone constitute a large and growing body of interesting scientific literature in many languages besides English. France, Germany, Spain, Italy, Russia, Algeria, Australia, British India, Brazil, and many other countries are represented here. Besides the reports of the stations, there are pamphlets published by various Governments, Commissions, and Departments in different countries, all bearing upon some department of agriculture. Nowhere else on the Pacific Coast can some of these publications be found on file.

Through the courtesy of editors and publishers the reading-rooms are supplied with a large number of dailies, weeklies, and monthlies, which are kept on file, and constantly referred to by students and instructors. The publications of the Department are sent in exchange, but in many cases the cost of the publications received far exceeds that of the bulletins sent out. We desire to return thanks to the kind friends who have contributed to the growth of our library and reading-room.

NEWSPAPERS RECEIVED AT STATION READING-ROOM.

CALIFORNIA.

Daily Encinal, Alameda, Alameda County.
Daily Herald, Berkeley, Alameda County.
Daily Advocate, Berkeley, Alameda County.
Washington Press, Irvington, Alameda County.
Weekly Herald, Livermore, Alameda County.
Amador Dispatch, Jackson, Amador County.
Chronicle-Record, Chico, Butte County.
Enterprise, Chico, Butte County.
Antioch Ledger, Martinez, Contra Costa County.
Contra Costa Gazette, Martinez, Contra Costa County.
Weekly Expositor, Fresno, Fresno County.
Weekly Republican, Fresno, Fresno County.
Enterprise, Ferndale, Humboldt County.
Lake County Avalanche, Lakeport, Lake County.
California Cultivator and Poultry Keeper, Los Angeles, Los Angeles County.
Rural Californian, Los Angeles, Los Angeles County.
Weekly Herald, Los Angeles, Los Angeles County.
L'Union Nouvelle, Los Angeles, Los Angeles County.

Le Progrés, Los Angeles, Los Angeles County.
Weekly Times, Pomona, Los Angeles County.
Santa Monica Outlook, Santa Monica, Los Angeles County.
Gonzales Tribune, Gonzales, Monterey County.
Weekly Index, Salinas, Monterey County.
Weekly Register, Napa, Napa County.
Foothill Tidings, Grass Valley, Nevada County.
Truckee Semi-Weekly Republican, Truckee, Nevada County.
Press and Horticulturist, Riverside, Riverside County.
Weekly Bulletin, San Francisco.
Weekly Chronicle, San Francisco.
Weekly Examiner, San Francisco.
Weekly Post, San Francisco.
California Daily Demokrat (German), San Francisco.
The Occident, San Francisco.
California Orchard and Farm, San Francisco.
California Fruit-Grower, San Francisco.
The Monitor, San Francisco.
Pacific Rural Press, San Francisco.
Daily Weather Bulletins, U. S. Weather Bureau, San Francisco.
Dixon Tribune, Dixon, Solano County.
Chino Valley Champion, Chino, San Bernardino County.
Ontario Record, Ontario, San Bernardino County.
Orange Grower, Rialto, San Bernardino County.
Daily Courier, San Bernardino, San Bernardino County.
The Citrograph, Redlands, San Bernardino County.
Escondido Times, Escondido, San Diego County.
The Great Southwest, San Diego, San Diego County.
The Moon, Paso Robles, San Luis Obispo County.
Templeton Advance, Templeton, San Luis Obispo County.
Times-Gazette, Redwood City, San Mateo County.
Daily Independent, Santa Barbara, Santa Barbara County.
Los Gatos Mail, Los Gatos, Santa Clara County.
Daily Herald, San José, Santa Clara County.
California Prohibitionist, San José, Santa Clara County.
Fanciers' Monthly, San José, Santa Clara County.
Pacific Tree and Vine, Santa Clara, Santa Clara County.
Mountain Messenger, Downieville, Sierra County.
Petaluma Courier, Petaluma, Sonoma County.
Santa Rosa Republican, Santa Rosa, Sonoma County.
Sutter County Farmer, Yuba City, Sutter County.
Corning Observer, Corning, Tehama County.
Porterville Enterprise, Porterville, Tulare County.
Tulare County Register, Tulare, Tulare County.
Tulare County Times, Tulare, Tulare County.
Ventura Free Press, Ventura, Ventura County.
Four Corners, Wheatland, Yuba County.

OTHER STATES.

Florence Herald, Florence, Alabama.
Daily Herald, Phœnix, Arizona.
Field and Farm, Denver, Colorado.

Florida Agriculturist, DeLand, Florida.
Florida Farmer and Fruit-Grower, Jacksonville, Florida.
Monthly Florida Bulletin, Tallahassee, Florida.
Southern Farmer, Athens, Georgia.
Southern Cultivator and Dixie Farmer, Atlanta, Georgia.
American Florist, Chicago, Illinois, and New York.
Farm and Home, Chicago, Illinois, and Springfield, Massachusetts.
Farm, Field, and Fireside, Chicago, Illinois.
Farmers' Review, Chicago, Illinois.
Irrigation Age, Chicago, Illinois.
Hotel World, Chicago, Illinois.
Orange-Judd Farmer, Chicago, Illinois.
Prairie Farmer, Chicago, Illinois.
The Farmer's Magazine, Springfield, Illinois.
Clover Leaf, South Bend, Indiana.
Home and Farm, Louisville, Kentucky.
The Louisiana Planter, New Orleans, Louisiana.
Baltimore Weekly Sun, Baltimore, Maryland.
Maryland Farmer, Baltimore, Maryland.
American Cultivator, Boston, Massachusetts.
The Farm Poultry Monthly, Boston, Massachusetts.
New England Farmer, Boston, Massachusetts.
American Cheesemaker, Grand Rapids, Michigan.
Corner Stone, Lansing, Michigan.
Grange Visitor, Lansing, Michigan.
National Dairyman, Kansas City, Missouri.
Colman's Rural World, St. Louis, Missouri.
Hospodar (Bohemian), Omaha, Nebraska.
Mirror and Farmer, Manchester, New Hampshire.
Southwestern Farm and Orchard, Las Cruces, New Mexico.
Stock-Grower, Las Vegas, New Mexico.
Weekly New Mexican Review, Santa Fe, New Mexico.
Brooklyn Grocers' Gazette, Brooklyn, New York.
American Agriculturist, New York City, New York.
Irrigation Market, New York City, New York.
Mercantile and Exchange Advocate, New York City, New York.
Rural New Yorker, New York City, New York.
Scientific American, New York City, New York.
Weekly Tribune, New York City, New York.
Green's Fruit-Grower, Rochester, New York.
Vick's Illustrated Monthly Magazine, Rochester, New York.
American Bulletin and Scientific Farmer, Cincinnati, Ohio.
American Farmer and Farm News, Springfield, Ohio.
Farm and Fireside, Springfield, Ohio.
Womankind, Springfield, Ohio.
North Pacific Rural Spirit, Portland, Oregon.
Northwest Pacific Farmer, Portland, Oregon.
The Rural Northwest, Portland, Oregon.
Germantown Telegraph, Germantown, Pennsylvania.
Meehan's Monthly, Germantown, Pennsylvania.
Farm Journal, Philadelphia, Pennsylvania.
Ladies' Home Companion, Philadelphia, Pennsylvania.
Practical Farmer, Philadelphia, Pennsylvania.

The Sugar Beet, Philadelphia, Pennsylvania.
The Cotton Plant, Columbia, South Carolina.
Texas Farm and Ranch, Dallas, Texas.
Texas Stockman, San Antonio, Texas.
American Farm and Horticulturist, Richmond, Virginia.
Holstein-Fresian Register, Battleboro, Vermont.
The Ranch, North Yakima, Washington.
Daily Post-Intelligencer, Seattle, Washington.
Northwest Horticulturist, Tacoma and Seattle, Washington.
Hoard's Dairyman, Fort Atkinson, Wisconsin.

FOREIGN.

Agricultural Gazette of New South Wales, Sydney, N. S. W., Australia.
Garden and Field, Adelaide, S. A., Australia.
Tiroler Landwirthschaftliche Blætter, St. Michele, Austria.
Le Bas-Rhône, Paris, France.
Revue des Sciences Naturelles Appliquées, Paris, France.
Revue de Viticulture, Paris, France.
Deutsche Landwirthschaftliche Presse, Berlin, Germany.
La Agricultura, Guatemala.
Bolletino Mensile di Bachicoltura, Padova, Italy.
Bolletino dei Viticoltori Italiani, Rome, Italy.
Kongl. Landt-Bruks Akadamiens Handligar och Tedskrift, Stockholm, Sweden.

AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

For the Fiscal Year 1892-3.

		Cr.	Dr.
1893.			
	To receipts from the Treasurer of the United States, as per appropriation for year ending June 30, 1893, under Act of Congress approved March 2, 1887		$15,000 00
June 30—	By buildings ... Led., p. 2..	$696 17	
	By furniture ... Led., p. 32..	239 50	
	By freight and expressage ... Led., p. 53..	219 58	
	By incidental expenses ... Led., p. 63..	148 54	
	By labor ... Led., p. 73..	5,156 04	
	By postage and stationery ... Led., p. 102..	148 47	
	By salaries ... Led., p. 123..	5,787 02	
	By supplies ... Led., p. 134..	1,407 59	
	By tools, implements, and machinery ... Led., p. 153..	239 39	
	By traveling ... Led., p. 163..	438 35	
	By water supply ... Led., p. 173..	519 35	
	Totals	$15,000 00	$15,000 00

We, the undersigned, duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1893; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000, and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
I. W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement, to which this is attached, is a true copy from the books of account of the institution named.

J. J. HERR,
Auditor.

AGRICULTURAL EXPERIMENT STATIONS OF THE UNIVERSITY OF CALIFORNIA IN ACCOUNT WITH THE UNITED STATES APPROPRIATION.

For the Fiscal Year 1893-4.

		Cr.	Dr.
1894.			
	To receipts from the Treasurer of the United States, as per appropriation for year ending June 30, 1894, under act of Congress approved March 2, 1887		$15,000 00
June 30—By buildings	Led., p. 2	$379 10	
By furniture	Led., p. 33	40 10	
By freight and expressage	Led., p. 53	399 96	
By incidental expenses	Led., p. 63	75 31	
By labor	Led., p. 74	4,284 33	
By postage and stationery	Led., p. 103	256 80	
By salaries	Led., p. 124	5,799 96	
By supplies	Led., p. 134	2,909 11	
By tools, implements, and machinery	Led., p. 153	323 53	
By traveling	Led., p. 163	352 70	
By water supply	Led., p. 173	179 10	
Totals		$15,000 00	$15,000 00

We, the undersigned duly appointed members of the Finance Committee of the Regents of the University of California, do hereby certify that we have examined the books and accounts of the Experiment Stations of the University of California, for the fiscal year ending June 30, 1894; that we have found the same well and correctly kept and classified as above, and that the receipts for the time named are shown to have been $15,000 and the corresponding disbursements $15,000, for all of which proper vouchers are on file, and have been by us examined and found correct.

A. S. HALLIDIE,
ALBERT MILLER,
ISAIAS W. HELLMAN,
Finance Committee of the Regents of the University of California.

I hereby certify that the foregoing statement to which this is attached is a true copy from the books of account of the institution named.

JOHN J. HERR,
Auditor.

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A

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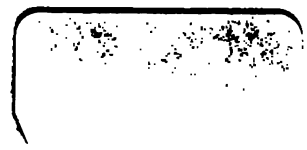
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